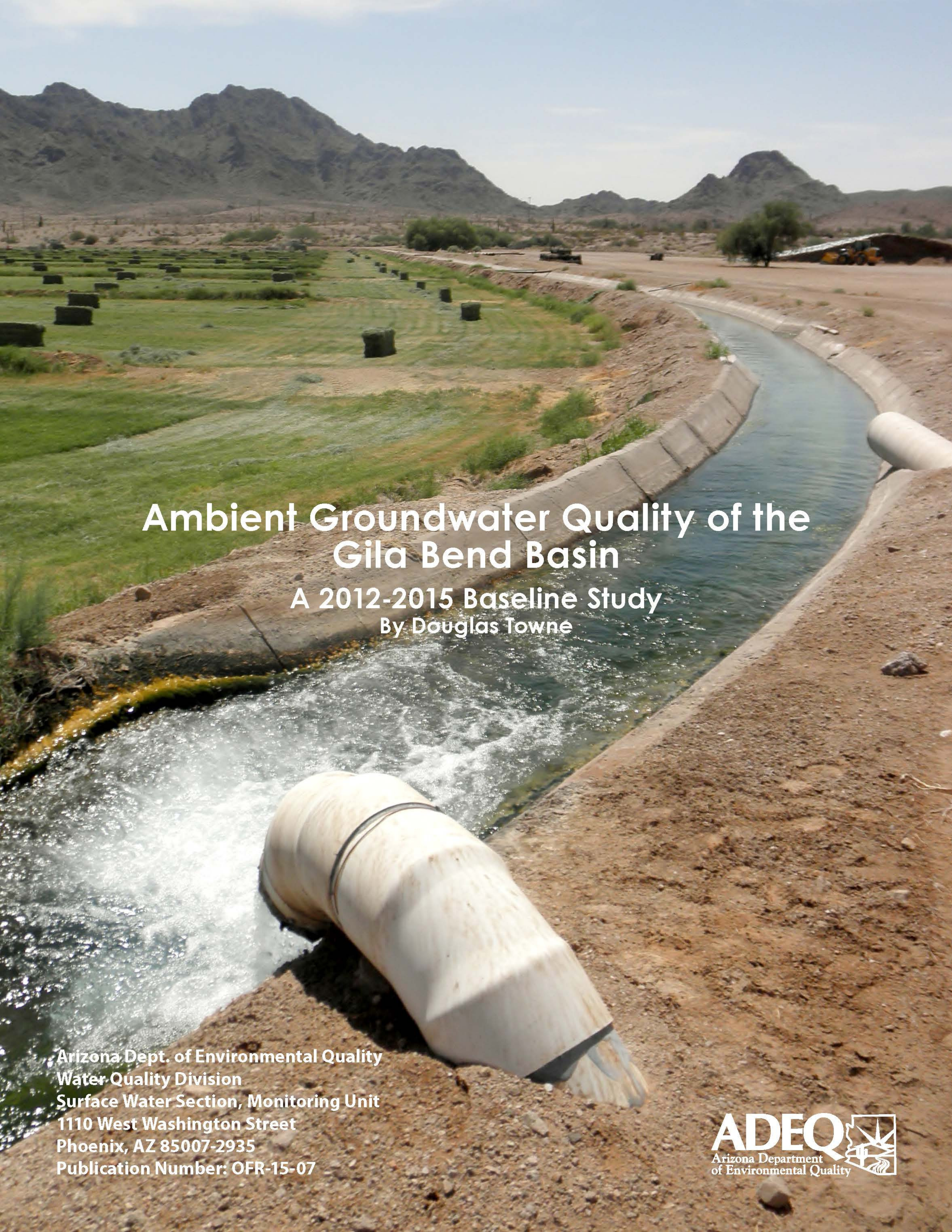

Ambient Groundwater Quality of the Gila Bend Basin

A 2012-2015 Baseline Study

By Douglas Towne

Arizona Dept. of Environmental Quality
Water Quality Division
Surface Water Section, Monitoring Unit
1110 West Washington Street
Phoenix, AZ 85007-2935
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ADEQ
Arizona Department
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Open File Report 15-07

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Thanks:

Field Assistance: Elizabeth Boettcher, Jade Dickens, Colin Millar, and Patti Spindler. Thanks to Kimberly Beisner and Henry Sanger of the U.S. Geological Survey for collecting a split sample. Special recognition is extended to the many well owners who gave their permission to collect groundwater data on their property.

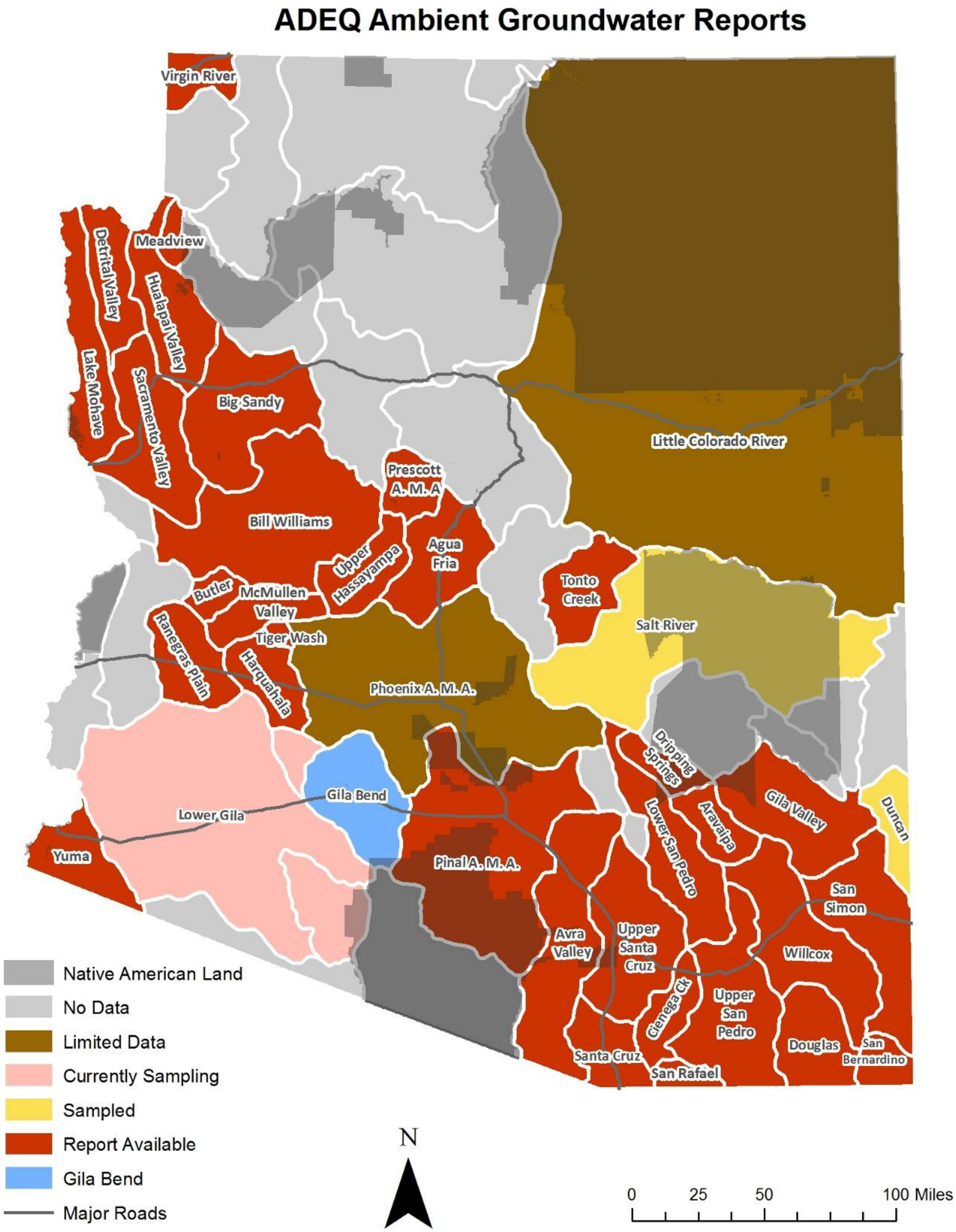
Photo Credits: Douglas Towne

Report Cover: Groundwater pumped from the River Well (GIL-52) pours into a ditch that irrigates an alfalfa field west of the Gila River in the Cotton Center hydrologic area. The well was one of 77 wells sampled to characterize the groundwater quality of the Gila Bend basin located about 50 miles southwest of Phoenix.

ADEQ Ambient Groundwater Quality Open-File Reports (OFR) and Factsheets (FS):

Tiger Wash Basin	OFR 14-07, 33 p.	FS 14-20, 4 p.
Avra Valley Sub-basin of the Tucson AMA	OFR 14-06, 63 p.	FS 14-11, 5 p.
Harquahala Basin	OFR 14-04, 62 p.	FS 14-09, 5 p.
Tonto Creek Basin	OFR 13-04, 50 p.	FS 13-18, 4 p.
Upper Hassayampa Basin	OFR 13-03, 52 p.	FS 13-11, 3 p.
Aravaipa Canyon Basin	OFR 13-01, 46 p.	FS 13-04, 4 p.
Butler Valley Basin	OFR 12-06, 44 p.	FS 12-10, 5.p.
Cienega Creek Basin	OFR 12-02, 46 p.	FS 12-05, 4.p.
Ranegras Plain Basin	OFR 11-07, 63 p.	FS 12-01, 4.p.
Groundwater Quality in Arizona	OFR 11-04, 26 p.	-
Bill Williams Basin	OFR 11-06, 77 p.	FS 12-01, 4.p.
San Bernardino Valley Basin	OFR 10-03, 43 p.	FS 10-31, 4 p.
Dripping Springs Wash Basin	OFR 10-02, 33 p.	FS 11-02, 4 p.
McMullen Valley Basin	OFR 11-02, 94 p.	FS 11-03, 6 p.
Gila Valley Sub-basin	OFR 09-12, 99 p.	FS 09-28, 8 p.
Agua Fria Basin	OFR 08-02, 60 p.	FS 08-15, 4 p.
Pinal Active Management Area	OFR 08-01, 97 p.	FS 07-27, 7 p.
Hualapai Valley Basin	OFR 07-05, 53 p.	FS 07-10, 4 p.
Big Sandy Basin	OFR 06-09, 66 p.	FS 06-24, 4 p.
Lake Mohave Basin	OFR 05-08, 66 p.	FS 05-21, 4 p.
Meadview Basin	OFR 05-01, 29 p.	FS 05-01, 4 p.
San Simon Sub-Basin	OFR 04-02, 78 p.	FS 04-06, 4 p.
Detrital Valley Basin	OFR 03-03, 65 p.	FS 03-07, 4 p.
San Rafael Basin	OFR 03-01, 42 p.	FS 03-03, 4 p.
Lower San Pedro Basin	OFR 02-01, 74 p.	FS 02-09, 4 p.
Willcox Basin	OFR 01-09, 55 p.	FS 01-13, 4 p.
Sacramento Valley Basin	OFR 01-04, 77 p.	FS 01-10, 4 p
Upper Santa Cruz Basin (w/ USGS)	OFR 00-06, 55 p.	-
Prescott Active Management Area	OFR 00-01, 77 p.	FS 00-13, 4 p.
Upper San Pedro Basin (w/ USGS)	OFR 99-12, 50 p.	FS 97-08, 2 p.
Douglas Basin	OFR 99-11, 155 p.	FS 00-08, 4 p.
Virgin River Basin	OFR 99-04, 98 p.	FS 01-02, 4 p.
Yuma Basin	OFR 98-07, 121 p.	FS 01-03, 4 p.

These publications are available at: www.azdeq.gov/environ/water/assessment/ambient.html



ADEQ Ambient Groundwater Monitoring Program Studies

Table of Contents

Maps

Tables

Diagrams

Figures

Abbreviations

amsl	above mean sea level
ac-ft	acre-feet
af/yr	acre-feet per year
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
ARRA	Arizona Radiation Regulatory Agency
AZGS	Arizona Geological Survey
As	arsenic
bls	below land surface
BLM	U.S. Department of the Interior Bureau of Land Management
CAP	Central Arizona Project
^{o}C	degrees Celsius
$CI_{0.95}$	95 percent Confidence Interval
Cl	chloride
EPA	U.S. Environmental Protection Agency
F	fluoride
Fe	iron
GIL	Gila Bend groundwater basin
gpm	gallons per minute
GWPL	Groundwater Protection List active ingredient
HCl	hydrochloric acid
LLD	Lower Limit of Detection
Mn	manganese
MCL	Maximum Contaminant Level
ml	milliliter
msl	mean sea level
ug/L	micrograms per liter
um	micron
µS/cm	microsiemens per centimeter at 25° Celsius
mg/L	milligrams per liter
MRL	Minimum Reporting Level
ns	not significant
ntu	nephelometric turbidity unit
pCi/L	picocuries per liter
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
SAR	Sodium Adsorption Ratio
SDW	Safe Drinking Water
SC	Specific Conductivity
su	standard pH units
SO_4	sulfate
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WQARF	Water Quality Assurance Revolving Fund
*	significant at $p \leq 0.05$ or 95% confidence level
**	significant at $p \leq 0.01$ or 99% confidence level

Ambient Groundwater Quality of the Gila Bend Basin: A 2012-2015 Baseline Study

Abstract - The Arizona Department of Environmental Quality (ADEQ) conducted a baseline groundwater quality study of the Gila Bend basin located in west-central Arizona about 50 miles southwest of Phoenix from 2012-2015. The basin comprises 1,284 square miles within Maricopa County and consists of a wide, gently sloping alluvial plain surrounded by fault-block mountains.[5] Irrigated agriculture is common in the fertile alluvial soils of the Gila River. Land ownership consists of federal lands (75 percent) managed by the Bureau of Land Management and the U.S. Military, private lands (16 percent), State Trust lands (six percent), and tribal lands (three percent). [5] The basin had a population of almost 4,256 people in 2000, many of who reside in the Town of Gila Bend.[5]

The basin is drained by the Gila River, an intermittent waterway that enters from the north at Gillespie Dam and, after a 36 miles stretch, exits to the west at Painted Rock Reservoir. All other washes in the basin are ephemeral and flow only after heavy precipitation.[19] The Gila River above Gillespie Dam is perennial and the water is normally diverted into the eight-mile Enterprise Canal on the west side, and the 35-mile Gila Bend Canal on the east side. Groundwater in the basin is contained in alluvial deposits that can be divided into younger and older alluvial units. These are considered to be a single aquifer because the units are hydrologically connected.[19] Groundwater is predominantly pumped for irrigation purposes with minor amounts used for public water, domestic, industrial, and stock uses.[5] The basin has five distinct hydrologic areas, each with a unique source of irrigation water or land use. The Enterprise and Paloma areas supplement Gila River water with groundwater for irrigation, Cotton Center and Painted Rock areas only use groundwater, and the Gila Bend area is located upgradient of agricultural activities.

For the study, 77 wells were sampled by ADEQ. They were used for irrigation (61), domestic (nine), public supply (six), and stock (one) purposes. Inorganic constituents and isotopes (oxygen, deuterium, and nitrogen) samples were collected at every well while radon (51) and radionuclide (19) samples were collected at selected sites.

Based on sample results, groundwater in the basin is generally not suitable for drinking water uses without proper treatment. Of the 77 sites sampled, none met all drinking water quality standards. Health-based, Primary Maximum Contaminant Levels (MCLs) were exceeded at 42 sites (55 percent). These enforceable standards define the maximum concentrations of constituents allowed in water supplied for drinking water purposes by a public water system and are based on a lifetime daily consumption of two liters.[29] Constituents exceeding these standards include nitrate (21 sites), arsenic (18 sites), fluoride (17 sites), and uranium (three sites). Arsenic and fluoride exceedances are caused by natural sources. Isotope values, however, suggest the main source for nitrate is animal waste. [24]

Aesthetics-based, Secondary MCLs were exceeded at all 77 sites. These are unenforceable guidelines that define the maximum constituent concentration that can be present in drinking water without an unpleasant taste, color, or odor.[29] Constituents exceeding Secondary MCLs include Total Dissolved Solids (TDS:77 sites), chloride (77 sites), fluoride (44 sites), sulfate (41 sites), aluminum (two sites), and pH-field (two sites). Elevated TDS concentrations have long characterized the basin's groundwater quality. TDS increases from high-salinity irrigation recharge, however, have been moderated by fresh recharge from major floods on the Gila River.[19] Of the 51 sites sampled for radon, 48 sites (94 percent) exceeded the proposed 300 picocuries per liter standard. [29]

Groundwater is commonly a sodium-chloride/mixed chemistry, *slightly-alkaline*, *slightly-to-moderately saline*, and *moderately-to-extremely hard*.[11, 13] Oxygen and deuterium isotope values of most samples are lighter and more depleted than would be expected from recharge occurring at elevations within the basin. This suggests that much of the groundwater was recharged long ago (8,000 to 12,000 years) during cooler climatic conditions[12]

Groundwater constituent concentrations were influenced by hydrologic area and recharge age.[12] Constituents such as oxygen-18, deuterium, temperature, pH, TDS, hardness, calcium, magnesium, sodium, potassium, bicarbonate, chloride, sulfate, nitrate, $\delta^{15}N$, arsenic, boron, fluoride, and strontium, had significantly different concentrations among hydrologic areas (Kruskal-Wallis with Tukey test, $p \leq 0.05$). Gila Bend and Paloma had the highest pH, arsenic, and fluoride concentrations; Enterprise generally had the highest TDS and major ion concentrations. Constituents such oxygen-18, deuterium, TDS, hardness, calcium, sodium, chloride, sulfate, nitrate, boron, copper, fluoride, selenium, and strontium had significantly higher constituent concentrations at sites with younger, enriched samples that at sites with older, depleted samples (Kruskal-Wallis test, $p \leq 0.05$).

INTRODUCTION

Purpose and Scope

The Gila Bend groundwater basin comprises approximately 1,284 square miles within western Maricopa County in the west central portion of the state (Map 1).[5] The basin is located about 50 miles southwest of Phoenix and is traversed by Interstate 8 (east-west) and Arizona Highway 85 (north-south). About half of the basin's populace resides in the Town of Gila Bend, which had a population of 1,977 people in 2013.[6] In 2000, the basin had an estimated population of 4,256.[5]

The basin is physically characterized by a wide, gently sloping alluvial plain centered on the Gila River, an intermittent waterway that enters from the north at Gillespie Dam (Figure 1) and exits to the west at Painted Rock Reservoir. There are no perennial streams or springs in the basin as all washes are ephemeral and flow only after heavy precipitation.[19] Groundwater is predominantly pumped for irrigation purposes with minor amounts used for public water, domestic, industrial, and stock uses.[6]

Sampling by the Arizona Department of Environmental Quality (ADEQ) Ambient Groundwater Monitoring program is authorized by legislative mandate in the Arizona Revised Statutes §49-225, specifically: "*...ongoing monitoring of waters of the state, including...aquifers to detect the presence of new and existing pollutants, determine compliance with applicable water quality standards, determine the effectiveness of best management practices, evaluate the effects of pollutants on public health or the environment, and determine water quality trends*."[3]

Benefits of ADEQ Study

This study is designed to provide the following benefits:

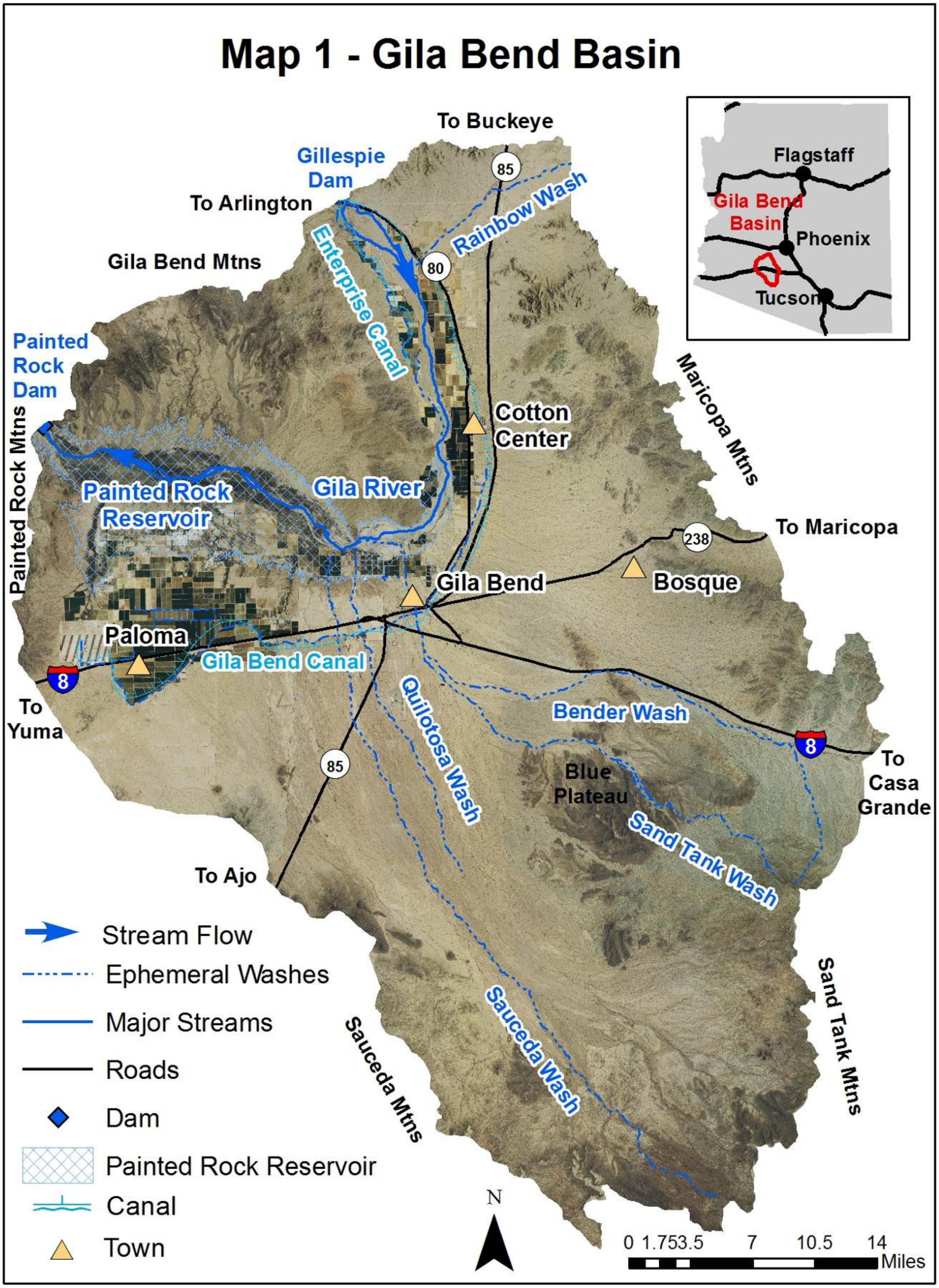
- Characterizing regional groundwater quality conditions in the Gila Bend basin.
- Identifying water quality variations between groundwater of different ages and hydrologic groups.
- Evaluating potential groundwater quality impacts arising from mineralization, irrigation, livestock, septic tanks, and improper well construction.
- Identifying further groundwater quality research needs.

Physical and Cultural Resources

The Gila Bend basin is located within the Basin and Range physiographic province of central Arizona. The basin is characterized by broad washes and a series of low, fault-block mountain ranges. In general, Precambrian granite and metamorphic rocks primarily occur in the northeastern portion of the basin while volcanic rocks and basalt are prevalent elsewhere in the bedrock geology.[23]The depth to bedrock has been estimated to be several thousand feet thick and appears to be deepest near the Town of Gila Bend. Vegetation consists of Lower Colorado River Valley and Arizona uplands Sonoran desert scrub.[5]

The basin is bounded on the north by the Gila Bend Mountains and the Buckeye Hills, on the west by the Painted Rock Mountains, on the south by the Sauceda Mountains, and on the east by the Maricopa and Sand Tank mountains. Elevations range from a high of approximately 3,183 feet above mean sea level (amsl) in the Maricopa Mountains to a low of approximately 660 feet amsl at Painted Rock Reservoir where the Gila River exits the basin.[19]

Figure 1 - The Paloma Irrigation and Drainage District (PIDD) uses pumps to convey surface water into the Gila Bend Canal from the Gila River since Gillespie Dam was breached by floodwaters in 1993.[19]



Map 1 - Gila Bend Basin
To Buckeye
Gillespie Dam
To Arlington
Rainbow Wash
Enterprise Canal
Gila Bend Mtns
Painted Rock Dam
Painted Rock Mtns
Painted Rock Reservoir
Gila River
Cotton Center
Maricopa Mtns
To Maricopa
Bosque
Gila Bend
Paloma
Gila Bend Canal
To Yuma
Quilotosa Wash
Bender Wash
Blue Plateau
Sand Tank Wash
To Casa Grande
To Ajo
Sauceda Mtns
Sauceda Wash
Sand Tank Mtns
Flagstaff
Gila Bend Basin
Phoenix
Tucson
85
80
238
8
Stream Flow
Ephemeral Washes
Major Streams
Roads
Dam
Painted Rock Reservoir
Canal
Town
N
0 1.753.5 7 10.5 14
Miles

Figure 2 – ADEQ's Elizabeth Boettcher collects a sample (GIL-8/42) from an irrigation well that supplements surface water diverted into the Enterprise Canal, located on the west side of the Gila River. This well was sampled twice, 15 months apart to examine for potential seasonal groundwater quality variation.

The Gila Bend basin borders the Phoenix Active Management Area (AMA) to the north, the Pinal AMA to the east, the San Simon Wash basin to the south, and the Lower Gila basin to the west.

Aside from a short intermittent stretch immediately downgradient of Gillespie Dam, the Gila River is ephemeral during its 36-mile stretch in the basin. The Gila River enters the basin from the north at Gillespie Dam, a former diversion facility that was breached during flooding in 1993.[5] The perennial flow reaching Gillespie Dam is the result of Phoenix-area wastewater treatment facilities and irrigation return.[19]

The Gila River exits the basin at Painted Rock Reservoir, which is a flood control structure that can hold 4.8 million acre-feet at maximum storage.[6] The mean annual discharge of the Gila River in the basin is highly variable, ranging from zero to over a million acre-feet per year.[5]

Other major ephemeral waterways in the basin include Bender, Quilotosa, Rainbow, Sand Tank, and Saucedo washes

Surface water from the Gila River at Gillespie Dam is now pumped into two canals for irrigation use: the Gila Bend Canal to the east and the Enterprise Canal to the west. The Enterprise Canal runs south about eight miles on the west side of the Gila River. The 35-mile Gila Bend Canal runs south to the Town of Gila Bend before turning and terminating west of Paloma. Both canals are supplemented by groundwater pumping.

Land Ownership - The Gila Bend basin consists of federal land (75.2 percent) managed by the U.S. Bureau of Land Management (BLM) (41.7 percent) and the U.S. Military (33.5 percent). The BLM's holdings include 238,700 acres of the 487,000 acre Sonoran Desert National Monument, which includes the North and South Mountain Maricopa wilderness areas and 49,000 acres of the 64,000-acre Woolsey Peak Wilderness. The U.S. Military lands are for the Barry Goldwater Air Force Range.[4,5]

The remainder of the basin is composed of private lands (15.7 percent), State Trust lands (6.2 percent), tribal lands (2.8 percent) of the San Lucy District of the Tohono O'odham Nation, and 0.1 percent owned by Maricopa County that is part of the Buckeye Hills County Park. Private and State lands are generally located along the rich agricultural parcels that follow the Gila River in a south-to-west path through the basin.[5]

Climate - The Gila Bend basin has a semiarid climate characterized by hot, dry summers and mild winters. Most of the basin receives less than eight inches of annual precipitation, though the extreme southeast receives up to 10 inches annually. Precipitation occurs predominantly as localized, late summer thunderstorms or as widespread, low intensity winter rain.[5]

Economy - Irrigated agriculture is historically the basin's most important economic activity. Traditional farming of alfalfa, cotton, and small grains has been recently augmented by new agricultural operations such as several large dairies and a fish farm. [5]

Other important economic sectors are the military facilities the U.S. Air Force operates, including the Gila Bend Auxiliary Air Field and the Barry F. Goldwater Bombing Range. The Town of Gila Bend refers to itself as "the Crossroads of the Southwest," for its connection to the many important transportation routes such as the historic Anza Historic Trail - Butterfield Stage Route. The town continues in this role, functioning as an important service center for motorists along Interstate 8 or Arizona State Route 85.

Power generation stations have recently located in the basin. These include the Gila River Power Station, a natural gas power plant operated by the Entegra Power Group. Many photovoltaic solar arrays are located in the basin. The largest is the Solana Generating Station which was completed in 2013. This is the largest parabolic trough plant in the world and the first U.S. solar plant with molten salt thermal energy storage. [35]

Another major employer is the Arizona Department of Corrections. The state agency operates the Arizona State Prison Complex – Lewis with a capacity of more than 4,300 inmates. [5]

Agriculture - Surface water from the Gila River was originally diverted at Gillespie Dam into the Enterprise Canal on the west side, and the Gila Bend Canal on the east side. Gillespie Dam was constructed in 1921 and diverted water until it was breached during high flows in 1993. Since then, pumps are used to lift water into the canals. [5, 19]

Significant groundwater development started with the drilling of several irrigation wells in 1935. Groundwater useage increased with 17 irrigation wells pumping 40,000 acre-feet (af) of water for crop irrigation by 1947. By 1965, 50 wells irrigated about 35,000 acres of farmland. Most wells were initially drilled near Cotton Center, located north of Gila Bend. Later, wells were drilled to the west of Gila Bend. [6]

There are five distinct hydrologic areas (Map 10):

- **Cotton Center** - an area on the east side of the Gila River downgradient from Gillespie Dam, and on the west side of the Gila River downgradient from the Enterprise Canal irrigated solely with groundwater.
- **Enterprise** - an area on the west side of the Gila River downgradient from Gillespie Dam irrigated with a combination of surface water from the Enterprise Canal and groundwater.
- **Gila Bend** – an area south and west of any irrigated agriculture that includes Gila Bend.
- **Painted Rock** - an area on the south side of the Gila River northwest of the Town of Gila Bend, irrigated solely with groundwater.
- **Paloma** - an area that encompasses the Paloma Irrigation and Drainage District, located west of the Town of Gila Bend, which is irrigated with a combination of surface water from the Gila Bend Canal which is supplemented by wells pumping groundwater along its route, along with groundwater.

Figure 3 – A sample (GIL-61) was collected from this public water supply well (#3) that serves the Gila Bend Air Force Auxiliary Field. Public works personnel at the base added the spigot located adjacent to the wellhead to meet ADEQ sampling requirements. The spigot created an access point for collecting freshly pumped water between the well and the base's large storage tank.

Groundwater Resources

Alluvial deposits in the basin can be divided into younger and older alluvial units. These are considered to be a single aquifer because both units yield water to wells and are hydrologically connected. [19]

Groundwater is unconfined except where fine-grained layers cause perched water table conditions resulting from percolation northwest of the Town of Gila Bend. Limited groundwater is also found in the surrounding mountains where thin alluvial deposits provide water to low-yield stock and domestic wells. [19]

Well yields in the alluvium vary widely depending on the substrate, ranging from several hundred gallons per minute (gpm) to more than 2,000 gpm. Sand and gravel beds in the alluvium provide higher well yields than fine grained beds. [6, 19]

Groundwater Characteristics

In the basin, groundwater typically moves from the mountain fronts towards the Gila River, then south and later west following the river's course. The exceptions to this general flow pattern are caused by areas of intensive groundwater pumping which has created several cones of depression. The largest cone of depression stretches from north of Cotton Center to Gila Bend paralleling the Gila River.[6]

Groundwater depth is typically shallowest near the Gila River and deepest near the mountain fronts. Groundwater levels vary from 15 feet bls near the Gila River to more than 600 feet bls. Over the past 20 years, groundwater levels have dropped by an average of 20 to 73 feet.[6] Of the 16 wells with water levels monitored by ADWR, 15 exhibited declining water levels with the largest drop being 147 feet. [36]

Well pumping for irrigated farming is the main cause of groundwater level declines in the basin. Though groundwater pumping is slowly depleting the aquifer, the amount of groundwater in storage, to a depth of 1,200 feet below land surface (bls), is estimated to be 27.6 million af. [6, 19]

Flow in the Gila River and water impounded behind Painted Rock Dam are the largest recharge sources in the basin. Other minor sources of recharge include infiltration of irrigation and canal water, underflow from the Gila River and its tributaries, and precipitation. [19]

Annual recharge in the basin is impacted by the variability of flow in the Gila River, which had a peak annual flow of 5.7 million af in 1983.[6] Heavy flows in the Gila River that occurred in 1973, 1978, 1979, and 1993 recharged the aquifer allowing groundwater levels to rise.[6, 19]

Predevelopment annual recharge was estimated at 37,000 af, current annual recharge is estimated at between 10 to 26,000 af/yr.[5] Recharge in the basin is likely declining, however, because of lower mean annual flows in the Gila River that are caused by factors including increased upstream water use and storage facilities. [29]

Figure 4 - ADEQ's Patti Spindler collects a sample (GIL-74) from Citrus Valley Well. Water produced by this well irrigates an alfalfa field located in the floodplain of the Gila River. These fields and well are submerged when Painted Rock Reservoir is filled to its maximum flood storage capacity of 4.8 million acre-feet. [6]

INVESTIGATION METHODS

ADEQ sampled 77 wells to characterize the regional groundwater quality in the Gila Bend basin (Map 2). The following types and numbers of samples were collected:

- inorganic suites at 77 sites
- oxygen and deuterium isotopes at 77 sites
- nitrogen isotopes at 77 sites
- radon at 51 sites
- radionuclides at 19 sites

Additional radon and radionuclides samples were not collected because of sampling budget constraints. The 77 wells sampled for the study were used for irrigation (61), domestic (9), public supply (6), and stock (1) purposes.

Figure 5 – The sample (GIL-89) obtained from this well, located just southeast of the Town of Gila Bend, was one of nine domestic wells included in the study. The majority of the people living in the basin are supplied with water provided by the Gila Bend Municipal Public Water System.

Each well was evaluated before sampling to determine if it met ADEQ requirements. A well was considered suitable for sampling when the following general conditions were met: the owner had given permission to sample, a sampling point existed near the wellhead, and the well casing and surface seal appeared to be intact and undamaged.[2, 7]

Additional information on groundwater sample sites compiled from the Arizona Department of Water Resources (ADWR) well registry is available in Appendix A.

Sample Collection

The sample collection methods for this study conformed to the *Quality Assurance Project Plan* (QAPP) [2] and the *Field Manual for Water Quality Sampling*.[7] While these sources should be consulted as references to specific sampling questions, a brief synopsis of the procedures involved in collecting a groundwater sample is provided.

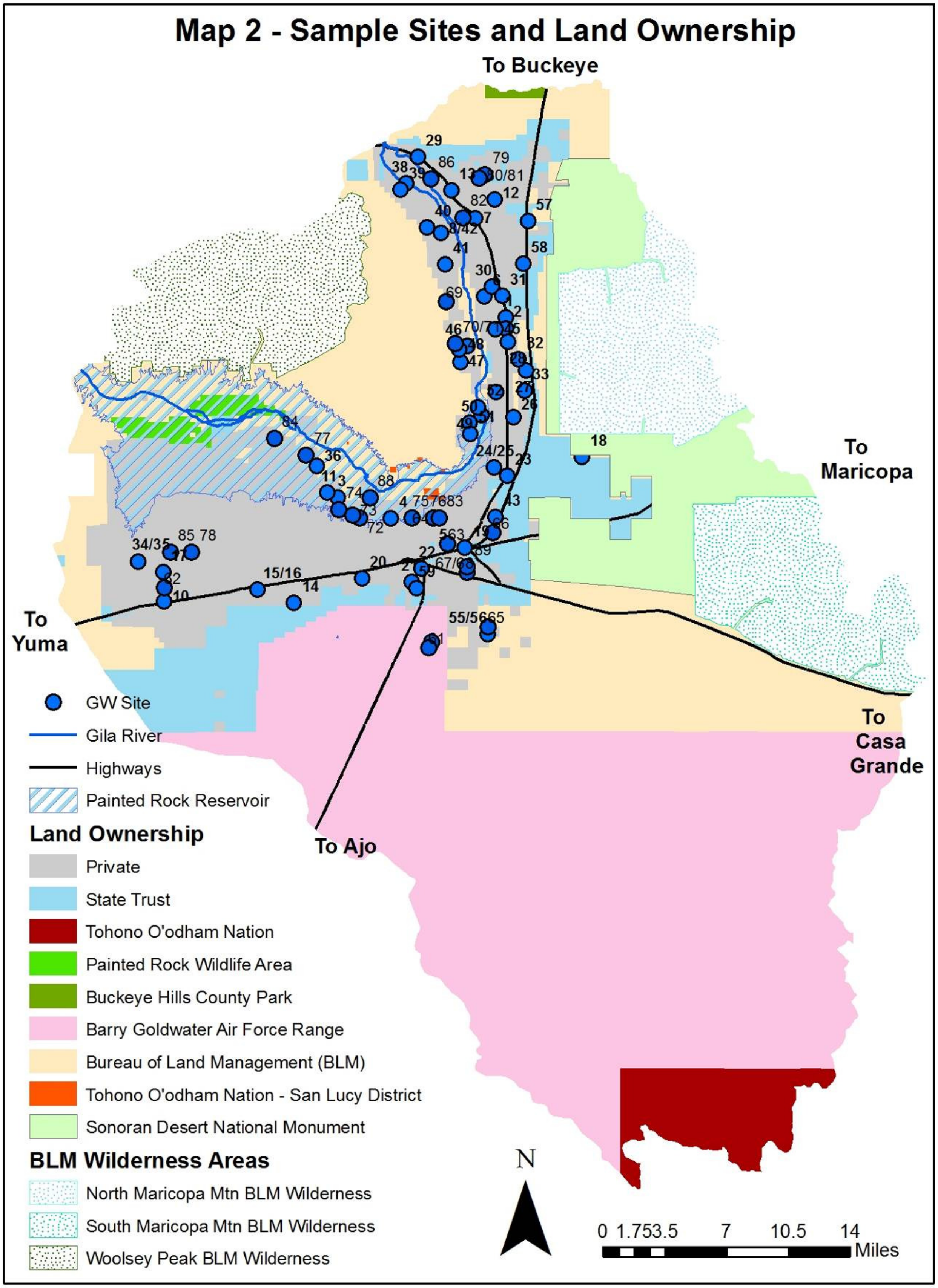
After obtaining permission from the well owner, the volume of water needed to purge the well three bore-hole volumes was calculated from well log and on-site information. Physical parameters—temperature, pH, and specific conductivity (SC)—were monitored approximately every five minutes using an YSI multi-parameter instrument.

To assure obtaining fresh water from the aquifer, after three bore volumes had been pumped and physical parameter measurements had stabilized within 10 percent, a sample representative of the aquifer was collected from a point as close to the wellhead as possible. In certain instances, it was not possible to purge three bore volumes. In these cases, at least one bore volume was evacuated and the physical parameters had stabilized within 10 percent.

Sample bottles were labeled with the Gila Bend prefix (GIL) and filled in the following order:

1. Radon
2. Inorganics
3. Radionuclide
4. Isotopes

Radon, a naturally occurring, intermediate breakdown from the radioactive decay of uranium-238 to lead-206, was collected in two unpreserved, 40 milliliter (ml) clear glass vials. Radon samples were filled to minimize volatilization and sealed so that no headspace remained.[1, 25]



Map 2 - Sample Sites and Land Ownership
To Buckeye
To Maricopa
To Yuma
To Casa Grande
To Ajo
GW Site
Gila River
Highways
Painted Rock Reservoir
Land Ownership
Private
State Trust
Tohono O'odham Nation
Painted Rock Wildlife Area
Buckeye Hills County Park
Barry Goldwater Air Force Range
Bureau of Land Management (BLM)
Tohono O'odham Nation - San Lucy District
Sonoran Desert National Monument
BLM Wilderness Areas
North Maricopa Mtn BLM Wilderness
South Maricopa Mtn BLM Wilderness
Woolsey Peak BLM Wilderness
N
0 1.75 3.5 7 10.5 14
Miles

Figure 6 – ADEQ's Colin Millar collects a radionuclide sample (GIL-62) from a PIDD irrigation well located adjacent to a dairy. Analytical results from the 19 radionuclide samples revealed only three sites where the Safe Drinking Water (SDW) standard for uranium was exceeded.

The inorganic constituents were collected in three, one-liter polyethylene bottles. Samples to be analyzed for dissolved metals were filtered into a bottle using a positive pressure filtering apparatus with a 0.45 micron (µm) pore size groundwater capsule filter and preserved with 5 ml nitric acid (70 percent). Samples to be analyzed for nutrients were preserved with 2 ml sulfuric acid (95.5 percent). Samples to be analyzed for other inorganic parameters were unpreserved.[1, 25]

Radiochemistry samples were collected in one collapsible four-liter plastic container [1, 25]

Oxygen and hydrogen isotope samples were collected in a 250 ml polyethylene bottle with no preservative.[31] Nitrogen isotope samples were collected in a 500 ml polyethylene bottle and filled ¾ full to allow room for expansion when frozen.[28]

All samples were kept at 4^{o} Celsius with ice in an insulated cooler, with the exception of the radionuclide, and oxygen and hydrogen isotope samples.[28] Nitrogen samples were frozen upon returning from the field and maintained in that manner until submitted to the laboratory.[28]

Chain of custody procedures were followed in sample handling. Samples for this study were collected during 11 field trips conducted between December 2012 and March 2015.

Laboratory Methods

Inorganic analyses for the study were conducted by two laboratories. The initial 52 inorganic samples (GIL-1 to GIL-59) were analyzed by Test America Laboratory of Phoenix, Arizona. Inorganic analyses for the subsequent 25 samples (GIL-60 to GIL-89) were analyzed by the Accutest Northern California Laboratory in San Jose, California. A complete listing of inorganic parameters, including laboratory method and Minimum Reporting Level (MRL) for each laboratory is provided in Table 1. The provided MRL for the labs, however, was their goal and not always achieved in practice.

Radionuclide and radon analyses were conducted by Radiation Safety Engineering, Inc. Laboratory in Chandler, Arizona.[1, 25]

Isotope samples were analyzed by the Laboratory of Isotope Geochemistry at the University of Arizona in Tucson, Arizona.[28]

Table 1. Laboratory Water Methods and Minimum Reporting Levels Used in the Study

Constituent	Instrumentation	Test America / Accutest Water Method	Test America/ Accutest Minimum Reporting Level
Physical Parameters and General Mineral Characteristics			
Alkalinity	Electrometric Titration	SM 2320B	6 / 5
SC (µS/cm)	Electrometric	SM 2510 B	2 / 1
Hardness	Calculation	SM 2340B	13 / 33
pH (su)	Electrometric	SM 4500H+	1.68 / -
TDS	Gravimetric	SM 2540C	20 / 10
Turbidity (NTU)	Nephelometric	EPA 180.1 / SM 2130B	0.2 / 0.5
Major Ions			
Calcium	ICP-AES	EPA 200.7	2 / 5
Magnesium	ICP-AES	EPA 200.7	2 / 5
Sodium	ICP-AES	EPA 200.8	2 / 10
Potassium	Flame AA	EPA 200.8	2 / 0.5
Bicarbonate	Calculation	Calculation - SM 2320B	-
Carbonate	Calculation	Calculation - SM 2320B	-
Chloride	Potentiometric Titration	EPA 300.0	20 / 50
Sulfate	Colorimetric	EPA 300.0	20 / 5
Nutrients			
Nitrate as N	Colorimetric	EPA 300.0	0.2 / 0.1
Nitrite as N	Colorimetric	EPA 300.0	0.2 / 0.1
Ammonia	Colorimetric	SM 4500NH-3D	0.05 / 1.0
TKN	Colorimetric	EPA 351.2 / SM 4500	1.0 / 0.2
Total Phosphorus	Colorimetric	SM 4500-P / SM 4500	0.1 / 0.02

All units are mg/L except as noted
Source [1, 25]

Table 1. Laboratory Water Methods and Minimum Reporting Levels Used in the Study-Continued

Constituent	Instrumentation	Test America / Accutest Water Method	Test America/ Accutest Minimum Reporting Level
Trace Elements			
Aluminum	ICP-AES	EPA 200.7	0.2
Antimony	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.003 / 0.006
Arsenic	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.003 / 0.01
Barium	ICP-AES	EPA 200.8 / EPA 200.7	0.001 / 0.2
Beryllium	Graphite Furnace AA	EPA 200.7	0.001 / 0.005
Boron	ICP-AES	EPA 200.7	0.2 / 0.1
Cadmium	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.001 / 0.002
Chromium	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.002 / 0.01
Copper	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.003 / 0.01
Fluoride	Ion Selective Electrode	EPA 300.0	0.4 / 0.1
Iron	ICP-AES	EPA 200.7	0.1 / 0.2
Lead	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.001 / 0.01
Manganese	ICP-AES	EPA 200.7	0.01 / 0.015
Mercury	Cold Vapor AA	EPA 245.1	0.0002
Nickel	ICP-AES	EPA 200.7	0.01 / 0.005
Selenium	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.002 / 0.01
Silver	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.001 / 0.005
Strontium	ICP-AES	EPA 200.7	0.1 / 0.01
Thallium	Graphite Furnace AA	EPA 200.8 / EPA 200.7	0.001 / 0.01
Zinc	ICP-AES	EPA 200.7	0.05 / 0.02
Radionuclides			
Gross alpha	Gas flow counter	EPA 900.0	varies
Radium 226	Gas flow counter	EPA 903.0	varies
Radium 228	Gas flow counter	EPA 904.0	varies
Radon	Liquid scantill. counter	EPA 913.1	varies
Uranium	Kinetic phosphorimeter	EPA Laser Phosphorimetry	varies

All units are mg/L Source [1, 25]

DATA EVALUATION

Quality Assurance

Quality-assurance (QA) procedures were followed and quality-control (QC) samples were collected to quantify data bias and variability for the Gila Bend basin study. The design of the QA/QC plan was based on recommendations provided in the *Quality Assurance Project Plan* (*QAPP*) and *the Field Manual For Water Quality Sampling*.[2, 7]

The following types and numbers of QC inorganic samples collected for this study:

- three equipment blanks,
- four duplicate samples,
- three split samples, and
- one well was sampled twice for time trend data.

Equipment Blanks

Three equipment blanks for inorganic analysis were collected for the study to ensure adequate decontamination of sampling equipment, and that the filter apparatus and/or de-ionized water were not impacting groundwater quality sampling.[7]

The equipment blank sample for major ion and nutrient analyses were collected by filling unpreserved bottles with de-ionized water. The nutrient bottle was subsequently preserved with sulfuric acid. The equipment blank sample for dissolved metal analysis was collected using de-ionized water that had been filtered into a bottle and preserved with nitric acid.

Two equipment blanks were submitted to the Test America laboratory (GIL-9 and GIL-44) and one was submitted to the Accutest Lab (GIL-87). Lab analytical results were as follows:

- GIL-9: SC (22 umhos/cm) and nitrate (0.21 mg/L);
- GIL-44: chloride (0.30 mg/L), boron (0.036 mg/L), copper (0.0050 mg/L), TKN (3.3 mg/L), SC (12 umhos/cm), TDS (5.4 mg/L), ammonia (0.026 mg/L), and total phosphorus (0.23 mg/L); and
- GIL-87: SC (2.8 umhos/cm).

The equipment blanks had a mean SC concentration of 9 umhos/cm, which was less than one percent of the SC mean concentration for the study. This was not considered to significantly affect the sample results. The SC detections may have occurred when water passing through a de-ionizing exchange unit normally has an SC value of at least 1 uS/cm. Carbon dioxide from the air can also dissolve in de-ionized water with the resulting bicarbonate and hydrogen ions imparting the observed conductivity.[21]

Duplicate Samples

Duplicates are identical sets of samples collected from the same source at the same time and submitted to the same laboratory with different identification numbers, dates, and times. Data from duplicate samples provide a measure of variability from the combined effects of field and laboratory procedures.[7]

Duplicate samples were collected from sampling sites that were believed to have elevated or unique constituent concentrations as judged by SC and pH field values.

Seven duplicate samples were collected for this study. Five duplicate samples were submitted to the Test America laboratory and two duplicate samples to the Accutest laboratory. The analytical results were evaluated by examining the variability in constituent concentrations in terms of absolute levels and as the percent difference.

Analytical results from the Test America duplicate samples indicate that of the 40 constituents examined, 28 had concentrations above the MRL. The duplicate samples had a maximum variation or percent difference between constituents less than or equal to 10 percent. Constituents exceeding this acceptable level include turbidity (12 percent), zinc (13 percent), ammonia (14 percent), iron (19 percent), TKN (35 percent), and total phosphorus (54 percent) (Table 2).

Two constituents were detected in only one of the duplicate samples. Total phosphorus was detected in sample (GIL-25) at a concentration of 0.16 mg/L and not detected in the duplicate (GIL-24) at an MRL of 0.10 mg/L. Mercury was detected in sample (GIL-35) at a concentration of 0.00028 mg/L and not detected in the duplicate (GIL-34) at an MRL of 0.0002 mg/L.

Analytical results from the Accutest duplicate samples indicate that of the 40 constituents examined, 20 had concentrations above the MRL. The duplicate samples all had a maximum variation between constituents less than 10 percent (Table 3).

Table 2. Summary Results of Five Duplicate Samples from Test America Laboratory

Parameter	Number of Dup. Samples	Difference in Percent			Difference in Concentrations		
		Minimum	Maximum	Median	Minimum	Maximum	Median
Alk., Total	5	0 %	4 %	0 %	0	5	0
SC (µS/cm)	5	0 %	0 %	0 %	0	0	0
Hardness	5	0 %	5 %	4 %	0	200	10
pH (su)	5	0 %	0 %	0 %	0	0.02	0
TDS	5	0 %	3 %	1 %	0	100	10
Turbidity (ntu)	2	5 %	12 %	-	0.1	0.2	-
Calcium	5	0 %	5 %	2 %	0	80	1
Magnesium	5	0 %	3 %	1 %	0	2	0.3
Sodium	5	0 %	5 %	2 %	0	100	10
Potassium	5	0 %	3 %	0 %	0	0.2	0
Chloride	5	0 %	1 %	0 %	0	10	0
Sulfate	5	0 %	2 %	0 %	0	100	0
Ammonia	3	3 %	14 %	6 %	0.001	0.011	0.005
Nitrate (as N)	3	0 %	0 %	0 %	0	0	0
T. Phosphorus *	1	-	-	54 %	-	-	0.033
TKN	1	-	-	35 %	-	-	1.2
Arsenic	5	0 %	4 %	3 %	0	0.003	0.002
Barium	5	0 %	1 %	1 %	0	0.001	0.001
Boron	5	0 %	2 %	1 %	0	0.02	0.01
Copper	4	5 %	8 %	-	0.00009	0.0004	-
Chromium	3	0 %	5 %	4 %	0	0.001	0.0002
Fluoride	5	0 %	1 %	0%	0	0.1	0
Iron	2	7 %	19 %	-	0.008	0.019	-
Lead	1	-	-	4 %	-	-	0.00006
Manganese	1	-	-	10 %	-	-	0.001
Selenium	4	0 %	4 %	-	0.001	0.0001	-
Strontium	5	0 %	3 %	1 %	0	0.1	0.01
Zinc	2	3 %	13 %	-	0.001	0.001	-

All concentration units are mg/L except as noted with certain physical parameters.

Table 3. Summary Results of Two Duplicate Samples from Accutest Laboratory

Parameter	Number of Dup. Samples	Difference in Percent			Difference in Concentrations		
		Minimum	Maximum	Median	Minimum	Maximum	Median
Physical Parameters and General Mineral Characteristics							
Alk., Total	1	-	-	2 %	-	-	2.8
SC (µS/cm)	1	-	-	1 %	-	-	20
Hardness	2	0 %	0 %	-	1	10	-
pH (su)	1	-	-	0 %	-	-	0
TDS	2	1 %	2 %	-	40	110	-
Major Ions							
Calcium	2	0 %	0 %	-	0.1	2	-
Magnesium	2	0 %	0 %	-	0	0.6	-
Sodium	2	0 %	5 %	2 %	7	32	-
Potassium	2	1 %	2 %	-	0.1	0.18	-
Chloride	2	0 %	1 %	-	10	13	-
Sulfate	1	-	-	2 %	-	-	4
Nutrients							
Nitrate (as N)	2	0 %	7 %	-	0	2.5	-
Trace Elements							
Arsenic	2	1 %	5 %	-	0.0001	0.0011	-
Barium	2	0 %	0 %	-	0	0.0004	-
Boron	2	0 %	1 %	-	0	0.01	-
Copper	1	-	-	8 %	-	-	0.0036
Fluoride	1	-	-	2 %	-	-	0.2
Lead	1	-	-	4 %	-	-	0.00006
Strontium	2	1 %	2 %	-	0.19	0.2	-
Zinc	2	-	-	4 %	-	-	0.003

All concentration units are mg/L except as noted with certain physical parameters.

An irrigation well located north of Gila Bend was sampled on two occasions to examine the influence of time and growing season on constituent concentrations:

- GIL-8 collected in December 2012, and
- GIL-42 collected in March 2013.

All constituents detected in the original sample were detected in the subsequent sample. Constituent concentration variation was below 10 percent with the exception of copper (20 percent).

Split Samples

Splits are identical sets of samples collected from the same source at the same time that are submitted to two different laboratories to check for laboratory differences.[7] Two inorganic split samples were collected. The analytical results were evaluated by examining the variability in constituent concentrations in terms of absolute levels and as the percent difference.

One inorganic split sample (GIL-55/56) was distributed between the Test America and the U.S. Geological Survey labs.[31, 32] Analytical results indicate that of the 41 constituents examined, 23 had concentrations above MRLs for both the Test America and U.S. Geological Survey laboratories. The maximum variation or percent difference between constituents was acceptable at below 12 percent (Table 4).

The other inorganic split sample (GIL-70/71) was distributed between the Accutest and Test America labs. Analytical results indicate that of the 29 constituents examined, 17 had concentrations above MRLs for both the Accutest and Test America labs. The maximum variation between constituents was acceptable at below 13 percent except for sodium and barium (12 percent), potassium (13 percent), and arsenic (23 percent; Table 5).

Based on the results of the equipment blanks along with the duplicate, split, and time-trend samples collected for this study, no significant QA/QC problems were found with the groundwater quality data collected for the study.

Data Validation

The analytical work for this study was subjected to four QA/QC correlations.

Cation/Anion Balances - Water samples should theoretically exhibit electrical neutrality. Therefore, the sum of milliequivalents per liter (meq/L) of cations should equal the sum of meq/L of anions. However, this neutrality rarely occurs due to unavoidable variation inherent in all water quality analyses. Still, if the cation/anion balance is found to be within acceptable limits, it can be assumed there are no gross errors in concentrations reported for major ions.[15]

Figure 7 - Kimberly Beisner and Henry Sanger of the U.S. Geological Survey collect a split of the ADEQ duplicate sample (GIL-55/56) from the Gila Bend Municipal Public Water System Well #6. For all but three constituents, the maximum variation between laboratories was less than five percent. The U.S. Geological Survey was conducting a groundwater quality study on public water systems in the Southwest.

Table 4. Summary Results of One Split Sample between Test America /USGS Laboratories

Constituents	Number of Split Sites	Difference in Percent	Difference in Concentration
Physical Parameters and General Mineral Characteristics			
Alkalinity, total	1	1 %	2
SC (µS/cm)	1	3 %	55
Hardness	1	1 %	1
pH (su)	1	1 %	0.15
TDS	1	7 %	79
Major Ions			
Calcium	1	0 %	0.1
Magnesium	1	3 %	0.41
Sodium	1	2 %	6
Potassium	1	1 %	0.11
Chloride	1	2 %	4
Sulfate	1	1 %	2
Nutrients			
Nitrate as N	1	2 %	0.14
Trace Elements			
Arsenic	1	0 %	0
Barium	1	0 %	0.00004
Beryllium	1	11 %	0.00006
Boron	1	8 %	0.078
Chromium	1	3 %	0.006
Fluoride	1	2 %	0.12
Selenium	1	2 %	0.0004
Strontium	1	1 %	0.006
Other			
Radon 222 (pCi/L)	1	4 %	72
Deuterium (0/00)	1	0 %	0.4
Oxygen-18 (0/00)	1	1 %	0.18

All units are mg/L except as noted [31, 32]

Table 5. Summary Results of One Split Samples between Accutest/Test America Laboratories

Constituents	Number of Split Sites	Difference in Percent	Difference in Concentration
Physical Parameters and General Mineral Characteristics			
Alkalinity, total *	1	-	-
SC (µS/cm)	1	6 %	230
Hardness	1	7 %	47
pH (su)	1	1 %	0.18
TDS	1	4 %	100
Major Ions			
Calcium	1	7 %	11.4
Magnesium	1	7 %	3.9
Sodium	1	12 %	72
Potassium	1	13 %	1.8
Chloride	1	5 %	45
Sulfate	1	3 %	8
Nutrients			
Nitrate as N	1	5 %	0.4
Trace Elements			
Arsenic	1	23 %	0.002
Barium	1	12 %	0.012
Boron	1	7 %	0.072
Fluoride	1	3 %	0.1
Strontium	1	7 %	0.14

All units are mg/L except as noted
* - Alkalinity not tested for by Accutest Laboratory.

Figure 8 – The study's highest pH-field levels were recorded at the sample (GIL-78) collected from the PIDD W-12 well in the western part of the basin. The pH-field (8.54 su) and pH-lab (8.70 su) levels both exceeded the 8.50 su Secondary Maximum Contaminant Level (MCL) for pH. Elevated pH levels are often correlated with elevated arsenic and fluoride concentrations; both of these constituents exceeded their respective Primary MCLs in this sample.

Overall, cation/anion meq/L balances of Gila Bend basin samples were significantly correlated (regression analysis, $p \leq 0.01$). Of the 77 samples, the cation/anion balances could not be determined for eight samples (GIL-72 through GIL-79) because the samples were accidentally discarded by the laboratory before bicarbonate analyses were conducted.

Of the remaining 69 samples, all except two samples were within +/-11 percent and 35 samples were within +/- 5 percent:

- 61 samples had low cation/high anion sums, and
- Eight samples had high cation/low anion sums.

The two samples with large balance discrepancies were GIL-3 (47 percent) and GIL-4 (52 percent). They both had high anion sums. Although no analytical errors were found at the time by the Test America lab, later investigation indicates it's likely the problem was caused by sodium concentrations that were underreported.

SC-TDS Correlation and Ratio - Specific conductivity, measured both in the field and by contract laboratories, was significantly correlated with TDS concentrations measured by contract laboratories (regression analysis, $r = 0.96$, $p \leq 0.01$).

The TDS concentration in mg/L should be from 0.55 to 0.75 times the SC in µS/cm for groundwater up to several thousand TDS mg/L.[20] The 77 samples were within this ratio and those that were a bit outside could be attributed to elevated TDS concentrations. The relationship of TDS to SC becomes undefined with very high or low concentrations of dissolved solids.[15]

Other samples outside the ratio were attributed to elevated concentrations of specific anions. Groundwater high in bicarbonate and chloride will have a multiplication factor near the lower end of this range; groundwater high in sulfate may reach or even exceed the higher factor. [15]

SC Correlation - The SC measured in the field at the time of sampling was significantly correlated with the SC measured by contract laboratories (regression analysis, $r = 0.99$, $p \leq 0.01$).

pH Correlation - The pH values measured in the field using a YSI meter at the time of sampling (Figure 8) were significantly correlated with laboratory pH values (regression analysis, $r = 0.84$, $p \geq 0.01$) (Diagram 1).

Data Validation Conclusions - Based on the results of the four QA/QC checks, the groundwater quality data collected for the study was considered valid except for underreported sodium concentrations in samples GIL-3 and GIL-4.

Statistical Considerations

Various statistical analyses were used to examine the groundwater quality data of the study. All statistical tests were conducted using SYSTAT software.[34]

Data Normality - Data associated with 25 constituents were tested for non-transformed normality using the Kolmogorov-Smirnov one-sample test with the Lilliefors option.[8] Results of this test revealed that three of the 25 constituents examined were normally distributed: temperature, pH-lab, and bicarbonate.

Spatial Relationships - The non-parametric Kruskal-Wallis test using untransformed data was applied to investigate the hypothesis that constituent concentrations from sample sites having different groundwater ages or hydrologic groups were the same. The Kruskal-Wallis test uses the differences, but also incorporates information about the magnitude of each difference.[34] The null hypothesis of identical mean values for all data sets within each test was rejected if the probability of obtaining identical means by chance was less than or equal to 0.05.

If the null hypothesis was rejected for the tests conducted on the hydrologic group, the Tukey method of multiple comparisons on the ranks of data was applied. The Tukey test identified significant differences between constituent concentrations when compared to each possibility with each of the tests.[34] Both the Kruskal-Wallis and Tukey tests are not valid for data sets with greater than 50 percent of the constituent concentrations below the MRL.[14]

Constituent Correlation - In order to assess the strength of association between constituents, their concentrations were compared to each other using the non-parametric Kendall's tau-b test. Kendall's correlation coefficient varies between -1 and +1; with a value of +1 indicating that a variable can be predicted perfectly by a positive linear function of the other, and vice versa. A value of -1 indicates a perfect inverse or negative relationship.

The results of the Kendall's tau-b test were then subjected to a probability test to determine which of the individual pair wise correlations were significant.[34] The Kendall's tau-b test is not valid for data sets with greater than 50 percent of the constituent concentrations below the MRL.[14]

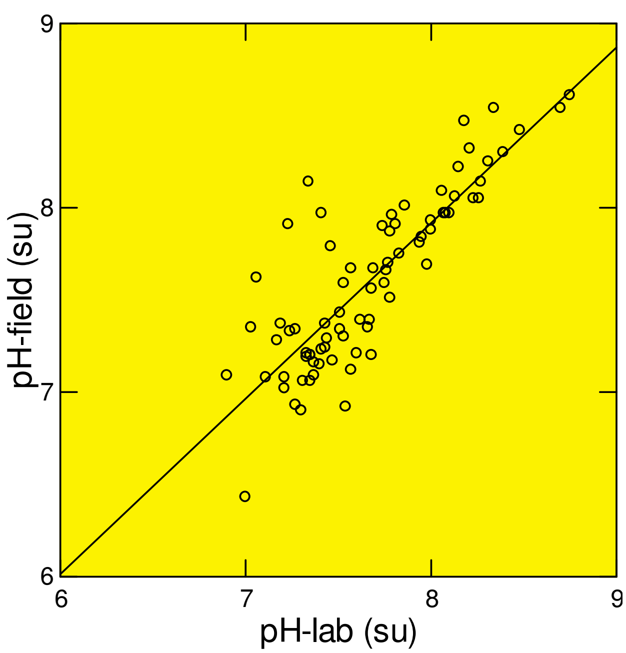


Diagram 1 – The graph illustrates a positive correlation between two constituents; as pH-field values increase, pH-lab values also increase. This relationship is described by the regression equation: $y = 0.74x + 2.03$ ($r = 0.84$). The pH value is closely related to the environment of the water and is likely to be altered by sampling and storage.[15] Still, the pH values measured in the field using a YSI meter at the time of sampling were significantly correlated with laboratory pH values. Factors including long aquifer residence time, which also tends to increase pH values.[22]

GROUNDWATER SAMPLING RESULTS

Water Quality Standards/Guidelines

The ADEQ ambient groundwater program characterizes regional groundwater quality. An important determination ADEQ makes concerning the collected samples is how the analytical results compare to various drinking water quality standards. ADEQ used three sets of drinking water standards that reflect the best current scientific and technical judgment available to evaluate the suitability of groundwater in the basin for drinking water use:

- Federal Safe Drinking Water Act (SDWA) Primary Maximum Contaminant Levels (MCLs). These enforceable health-based standards establish the maximum concentration of a constituent allowed in water supplied by public systems.[29]

- State of Arizona Aquifer Water Quality Standards. These apply to aquifers that are classified for drinking water protected use. All aquifers within Arizona are currently classified and protected for drinking water use. These enforceable state standards are identical to the federal Primary MCLs except for arsenic which is at 0.05 mg/L compared with the federal Primary MCL of 0.01 mg/L.[3]

- Federal SDWA Secondary MCLs. These non-enforceable aesthetics-based guidelines define the maximum concentration of a constituent that can be present without imparting unpleasant taste, color, odor, or other aesthetic effects on the water.[29]

Health-based drinking water quality standards (such as Primary MCLs) are based on the lifetime consumption (70 years) of two liters of water per day and, as such, are chronic rather than acute standards.[29] Exceedances of specific constituents for each groundwater site is found in Appendix B.

Overall Results – The 77 sites sampled in the Gila Bend study had the following water quality results:

- None met all health-based and aesthetics-based, water quality standards,

- Health-based water quality standards were exceeded at 42 sites (55 percent), and

- Aesthetics-based water quality standards were exceeded at 77 sites (100 percent).

Inorganic Constituent Results - Of the 77 sites sampled for the full suite of inorganic constituents (excluding radionuclide sample results) none met all health-based and aesthetics-based, water quality standards.

Health-based Primary MCL water quality standards were exceeded at 42 sites (55 percent) of the 77 sites (Map 3; Table 6). Constituents above Primary MCLs include nitrate (21 sites), arsenic (18 sites), fluoride (17 sites), and uranium (three sites). Potential impacts of these Primary MCL exceedances are given in Table 6.

Aesthetics-based Secondary MCL water quality guidelines were exceeded at all 77 sites (100 percent; Map 3; Table 7). Constituents above Secondary MCLs include TDS (77 sites), chloride (77 sites), fluoride (44 sites), sulfate (41 sites), aluminum (two sites), and pH-field (two sites). Potential impacts of these Secondary MCL exceedances are given in Table 7.

Radionuclide Results - Of the 19 sites sampled for radionuclides, three exceeded health-based water quality standards for uranium.

Radon Results - Of the 51 sites sampled for radon had the following water quality results (Map 4):

- The proposed 4,000 picocuries per liter (pCi/L) standard that would apply if Arizona were to establish an enhanced multimedia (air and water) program to address the health risks from radon in indoor air was not exceeded at any sites.
- The proposed 300 pCi/L standard that would apply if Arizona were not to develop a multimedia program was exceeded at 48 sites (94 percent).[30]

Analytical Results

Analytical inorganic and radiochemistry results of the Gila Bend sample sites are summarized (Table 8) using the following indices: MRLs, number of sample sites over the MRL, upper and lower 95 percent confidence intervals ($CI_{95\%}$), median, and mean. Confidence intervals are a statistical tool which indicates that 95 percent of a constituent's population lies within the stated confidence interval.[34] Specific constituent information for each sampled groundwater site is in Appendix B.

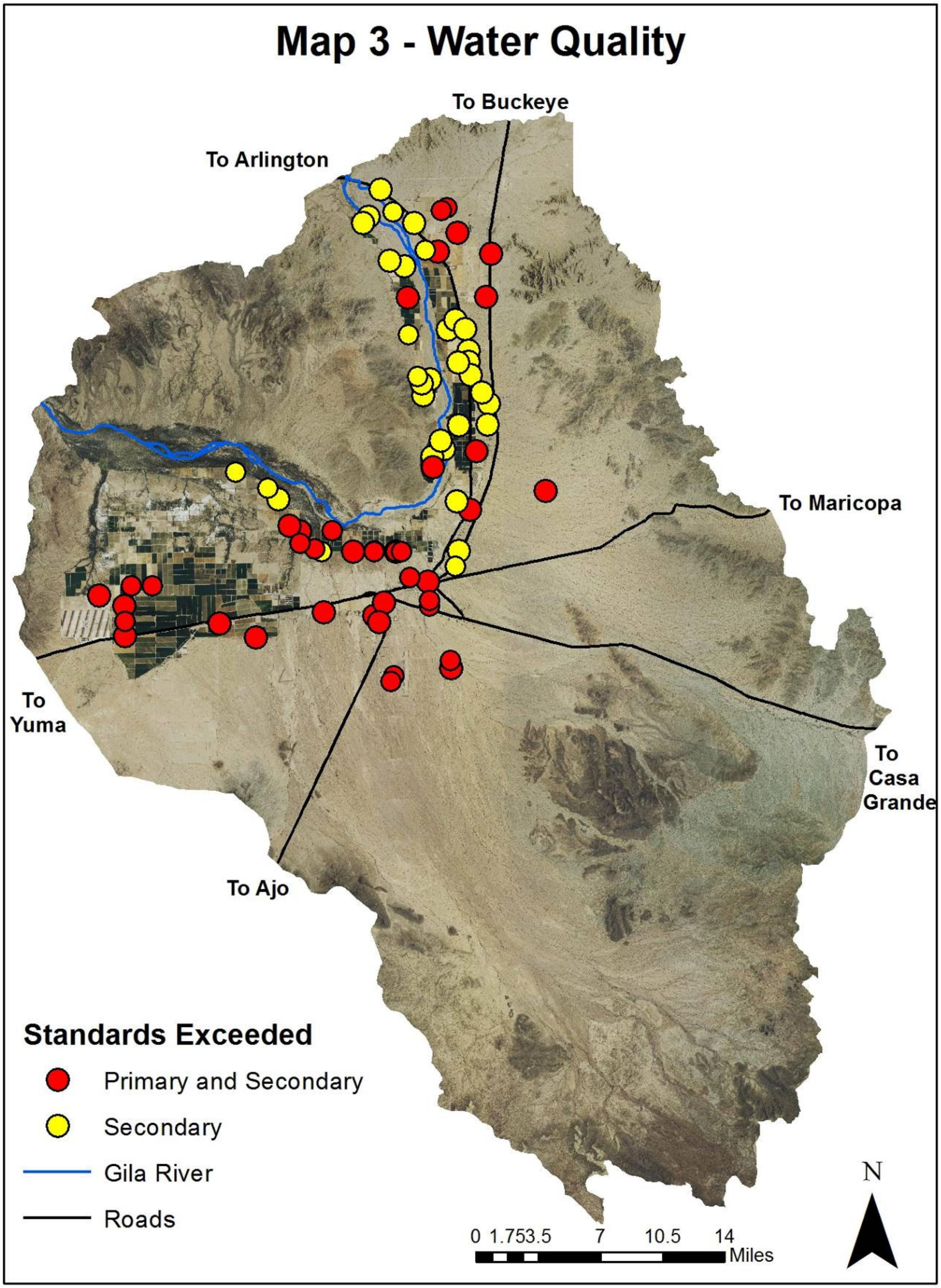

Map 3 - Water Quality
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Standards Exceeded
Primary and Secondary
Secondary
Gila River
Roads
N
0 1.753.5 7 10.5 14
Miles

Table 6. Sampled Sites Exceeding Health-based Water Quality Standards or Primary MCLs

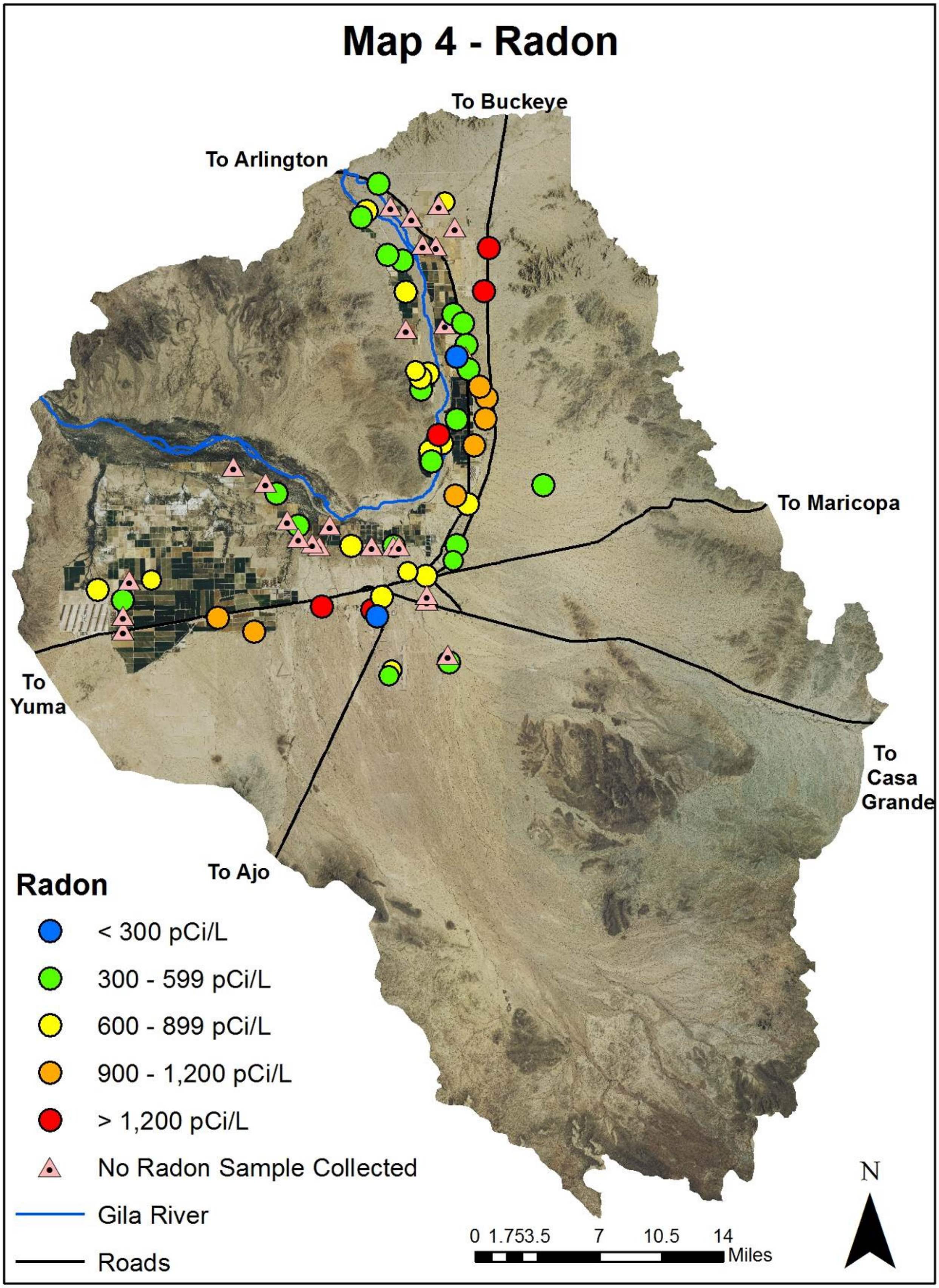
Constituent	Primary MCL	Number of Sites Exceeding Primary MCL	Maximum Concentration	Potential Health Effects of MCL Exceedances *
		Nutrients		
Nitrite (NO_2-N)	1.0	0	-	-
Nitrate (NO_3-N)	10.0	**21**	41.2	methemoglobinemia
		Trace Elements		
Antimony (Sb)	0.006	0	-	-
Arsenic (As)	0.01	**18**	0.0298	dermal and nervous system toxicity
Arsenic (As)	0.05	0	-	-
Barium (Ba)	2.0	0	-	-
Beryllium (Be)	0.004	0	-	-
Cadmium (Cd)	0.005	0	-	-
Chromium (Cr)	0.1	0	-	-
Copper (Cu)	1.3	0	-	-
Fluoride (F)	4.0	**17**	6.0	skeletal damage
Lead (Pb)	0.015	0	-	-
Mercury (Hg)	0.002	0	-	-
Nickel (Ni)	0.1	0	-	-
Selenium (Se)	0.05	0	-	-
Thallium (Tl)**	0.002	0	-	-
		Radiochemistry Constituents		
Gross Alpha	15	0	-	-
Ra-226+Ra-228	5	0	-	-
Radon **	300	**48**	2,134	cancer
Radon **	4,000	0	-	-
Uranium	30	**3**	280	cancer and kidney toxicity

All units are mg/L except gross alpha, radium-226+228 and radon (pCi/L), and uranium (ug/L).
* Health-based drinking water quality standards are based on a lifetime consumption of two liters of water per day over a 70-year life span.[29]
** Proposed EPA Safe Drinking Water Act standards for radon in drinking water. [29]

Table 7. Sampled Sites Exceeding Aesthetics-Based Water Quality Guidelines or Secondary MCLs

Constituents	Secondary MCL	Number of Sites Exceeding Secondary MCLs	Maximum Concentration	Aesthetic Effects of MCL Exceedances
Physical Parameters				
pH - field	< 6.5	0	-	-
pH - field	> 8.5	**2**	8.54	slippery feel; soda taste; deposits
General Mineral Characteristics				
TDS	500	**77**	7,700	hardness; deposits; colored water; staining; salty taste
Major Ions				
Chloride (Cl)	250	**77**	3,000	salty taste
Sulfate (SO_4)	250	**41**	2,350	salty taste
Trace Elements				
Aluminum (Al)	0.05 to 0.2	**2**	0.369	colored water
Fluoride (F)	2.0	**44**	6.0	tooth discoloration
Iron (Fe)	0.3	0	-	-
Manganese (Mn)	0.05	0	-	-
Silver (Ag)	0.1	0	-	-
Zinc (Zn)	5.0	0	-	-

All units mg/L except pH is in standard units (su). Source: [29]



Map 4 - Radon
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Radon
< 300 pCi/L
300 - 599 pCi/L
600 - 899 pCi/L
900 - 1,200 pCi/L
> 1,200 pCi/L
No Radon Sample Collected
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

Table 8. Summary Statistics for Groundwater Quality Data

Constituent	Minimum Reporting Limit (MRL)*	# of Samples / Samples Over MRL	Median	Lower 95% Confidence Interval	Mean	Upper 95% Confidence Interval
Physical Parameters						
Temperature (^{o}C)	0.1	77 / 77	28.1	27.2	28.1	28.9
pH-field (su)	0.01	77 / 77	7.59	7.50	7.60	7.71
pH-lab (su)	1.68 / -	77 / 77	7.60	7.58	7.67	7.76
Turbidity (ntu)	0.2 / 0.5	77 / 12	> 50 percent of data below MRL			
General Mineral Characteristics						
T. Alkalinity	6.0 / 5.0	77 / 69*	120	104	119	134
SC-field (µS/cm)	N/A	77 / 77	2952	3127	3559	3992
SC-lab (µS/cm)	2.0 / 1.0	77 / 77	3000	3223	3673	4123
Hardness-lab	13 / 33	77 / 77	580	504	635	766
TDS	20 / 10	77 / 77	1800	2074	2426	2777
Major Ions						
Calcium	2 / 5	77 / 77	180	167	209	251
Magnesium	2 / 5	77 / 65	27	29	39	50
Sodium	2 / 10	77 / 77	440	259	741	1222
Potassium	2 / 0.5	77 / 77	8.6	8.5	9.6	10.7
Bicarbonate	Calculation	77 / 69*	146	127	146	164
Carbonate	Calculation	77 / 0	> 50 percent of data below MRL			
Chloride	20 / 50	77 / 77	840	851	975	1099
Sulfate	20 / 5	77 / 77	260	327	418	508
Nutrients						
Nitrate (as N)	0.2 / 0.1	77 / 77	5.3	6.2	7.8	9.4
Nitrite (as N)	0.2 / 0.1	77 / 0	> 50% of data below MRL			
TKN	1.0 / 0.2	77 / 9	> 50% of data below MRL			
Ammonia	0.05 / 1.0	77 / 20	> 50% of data below MRL			
T. Phosphorus	0.1 / 0.02	77 / 20	> 50% of data below MRL			

* = Standard Test America / Accutest MRL but these sometimes can vary   All units mg/L except where noted.

Table 8. Summary Statistics for Groundwater Quality Data—Continued

Constituent	Minimum Reporting Limit (MRL)*	# of Samples / Samples Over MRL	Median	Lower 95% Confidence Interval	Mean	Upper 95% Confidence Interval
Trace Elements						
Aluminum	0.2	77 / 2		> 50% of data below MRL		
Antimony	0.003 / 0.006	77 / 0		> 50% of data below MRL		
Arsenic	0.003 / 0.01	77 / 57	0.005	0.006	0.007	0.009
Barium	0.001 / 0.2	77 / 68	0.051	0.045	0.55	0.064
Beryllium	0.001 / 0.005	77 / 0		> 50% of data below MRL		
Boron	0.2 / 0.1	77 / 77	0.97	1.03	1.25	1.47
Cadmium	0.001 / 0.002	77 / 0		> 50% of data below MRL		
Chromium	0.002 / 0.01	77 / 30		> 50% of data below MRL		
Copper	0.003 / 0.01	77 / 42		> 50% of data below MRL		
Fluoride	0.4 / 0.1	77 / 75	2.3	2.1	2.5	2.9
Iron	0.1 / 0.2	77 / 6		> 50% of data below MRL		
Lead	0.001 / 0.01	72 / 2		> 50% of data below MRL		
Manganese	0.01 / 0.015	77 / 4		> 50% of data below MRL		
Mercury	0.0002	77 / 1		> 50% of data below MRL		
Nickel	0.01 / 0.005	77 / 0		> 50% of data below MRL		
Selenium	0.002 / 0.01	77 / 54	0.003	- 0.005	0.017	0.039
Silver	0.001 / 0.005	77 / 3		> 50% of data below MRL		
Strontium	0.1 / 0.01	77 / 77	1.90	2.27	2.84	3.41
Thallium	0.001 / 0.01	77 / 2		> 50% of data below MRL		
Zinc	0.05 / 0.02	77 / 22		> 50% of data below MRL		
Radiochemical						
Gross α (pCi/L)	Varies	19 / 9		> 50% of data below MRL		
Uranium (pCi/L)	Varies	19 / 17	14.1	- 3.1	31.0	65.1
Radon (pCi/L)	Varies	51 / 51	705	630	736	842
Isotopes						
O-18 (0/00)	Varies	77 / 77	-9.00	-8.97	-8.89	-8.81
D (0/00)	Varies	77 / 77	-67.0	-67.2	-66.8	-66.2
$\delta^{15}N$ (0/00)	Varies	77/76	11.3	11.2	12.1	13.0

GROUNDWATER COMPOSITION

General Summary

Water chemistry was determined at 67 of the 77 sample sites, minus the 10 sites at which the water chemistry could not be resolved because of laboratory issues in the Gila Bend basin. In decreasing frequency, the water chemistry of the basin was sodium-chloride (59 sites) and mixed-chloride (eight sites) (Diagram 2 – middle figure) (Map 5).

The dominant cation was sodium at 59 sites (Diagram 2 – left figure). The dominant anion was chloride at 67 sites, (Diagram 2 – right figure).

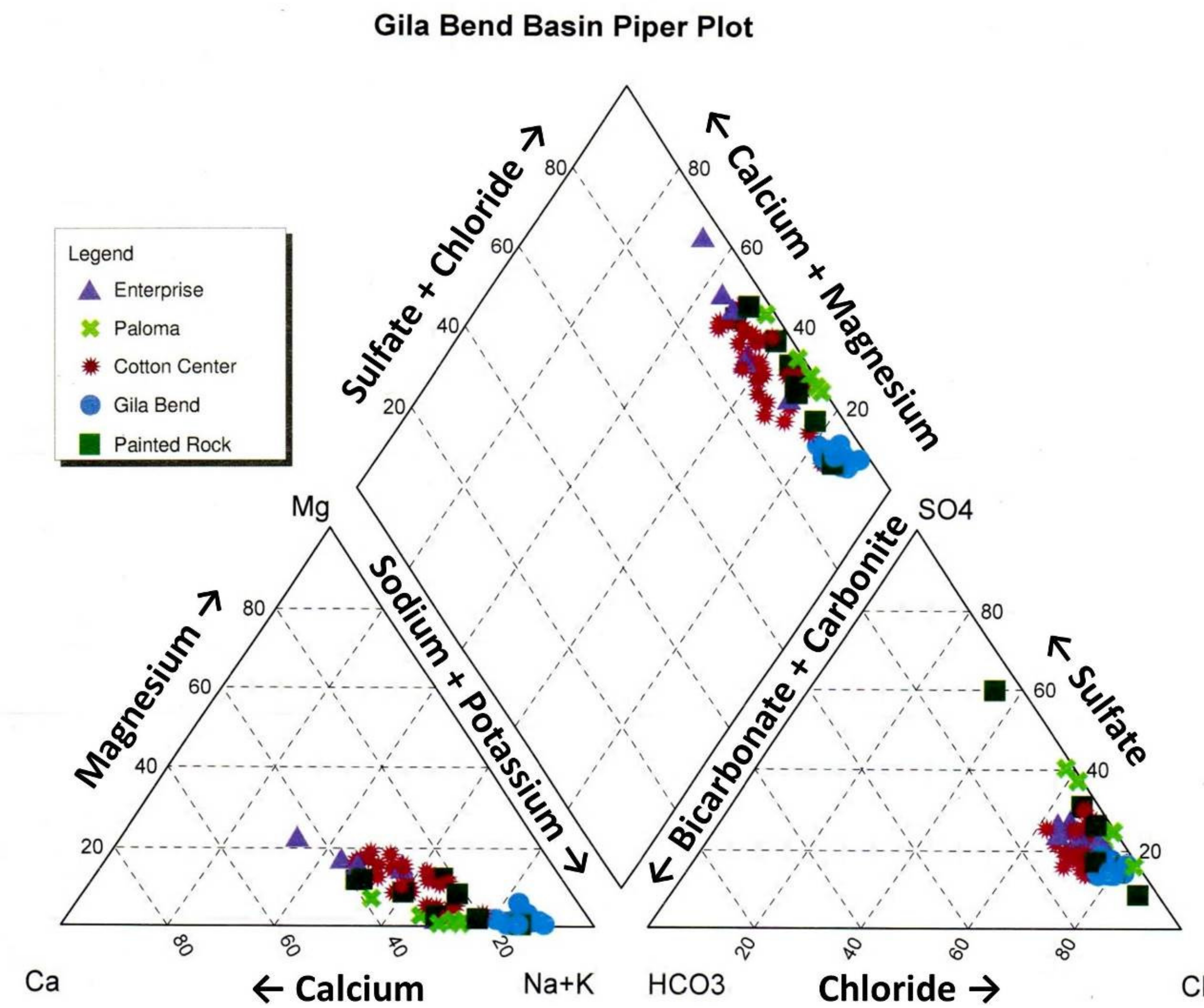
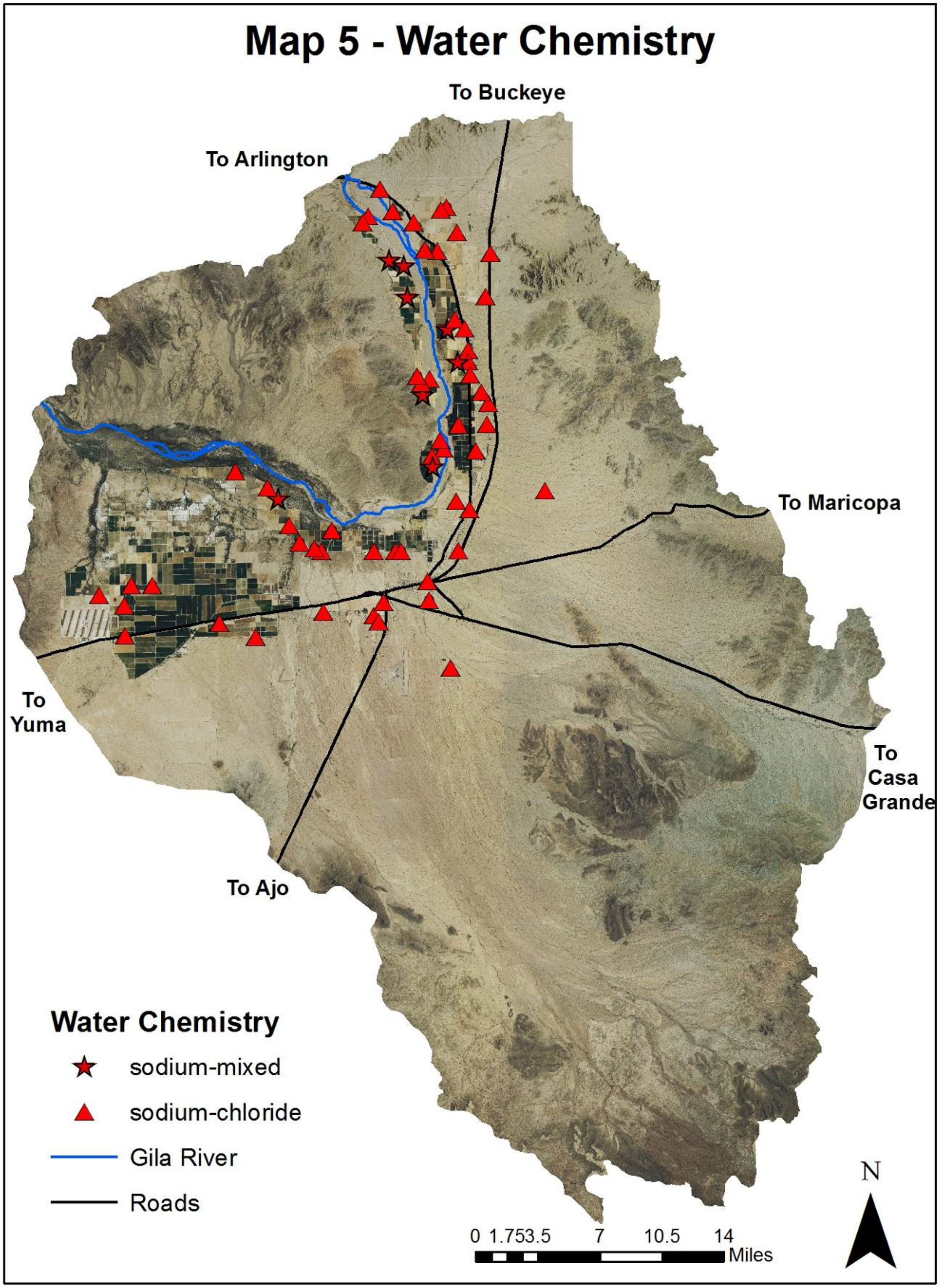


Diagram 2 – Samples collected in the Gila Bend basin are predominantly a sodium/mixed-chloride chemistry, which is reflective of older groundwater that has was recharged long ago. No sample sites had a calcium-bicarbonate chemistry which is characteristic of the most recent recharged groundwater.[22] *The piper diagram doesn't include samples GIL-72 through 79, which lacked bicarbonate results because of a lab error and GIL-3 and GIL-4, which had a large cation-anion imbalance that the lab was not able to resolve.*[25]


Map 5 - Water Chemistry
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Water Chemistry
sodium-mixed
sodium-chloride
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

At five sites, levels of pH-field were *slightly acidic* (below 7 su). At 56 sites, levels of pH-field were *slightly alkaline* (7 - 8 su) and 16 sites were above 8 su. [13]

TDS concentrations were considered *fresh* (below 999 mg/L) at two sites, *slightly saline* (1,000 to 3,000 mg/L) at 56 sites, and *moderately saline* (3,000 to 10,000 mg/L) at 19 sites (Map 6).[13]

Hardness concentrations were *soft* (below 75 mg/L) at one site, *moderately hard* (75 – 150 mg/L) at 11 sites, *hard* (150 – 300 mg/L) at 14 sites, *very hard* (301 - 600 mg/L) at 13 sites, and *extremely hard* (above 601 mg/L) at 38 sites (Map 7).[11]

Nitrate concentrations were divided into natural background (one site at < 0.2 mg/L), may or may not indicate human influence (22 sites at 0.2 – 3.0 mg/L), may result from human activities (33 sites at 3.0 – 10 mg/L), and probably result from human activities (21 sites at > 10 mg/L).[18]

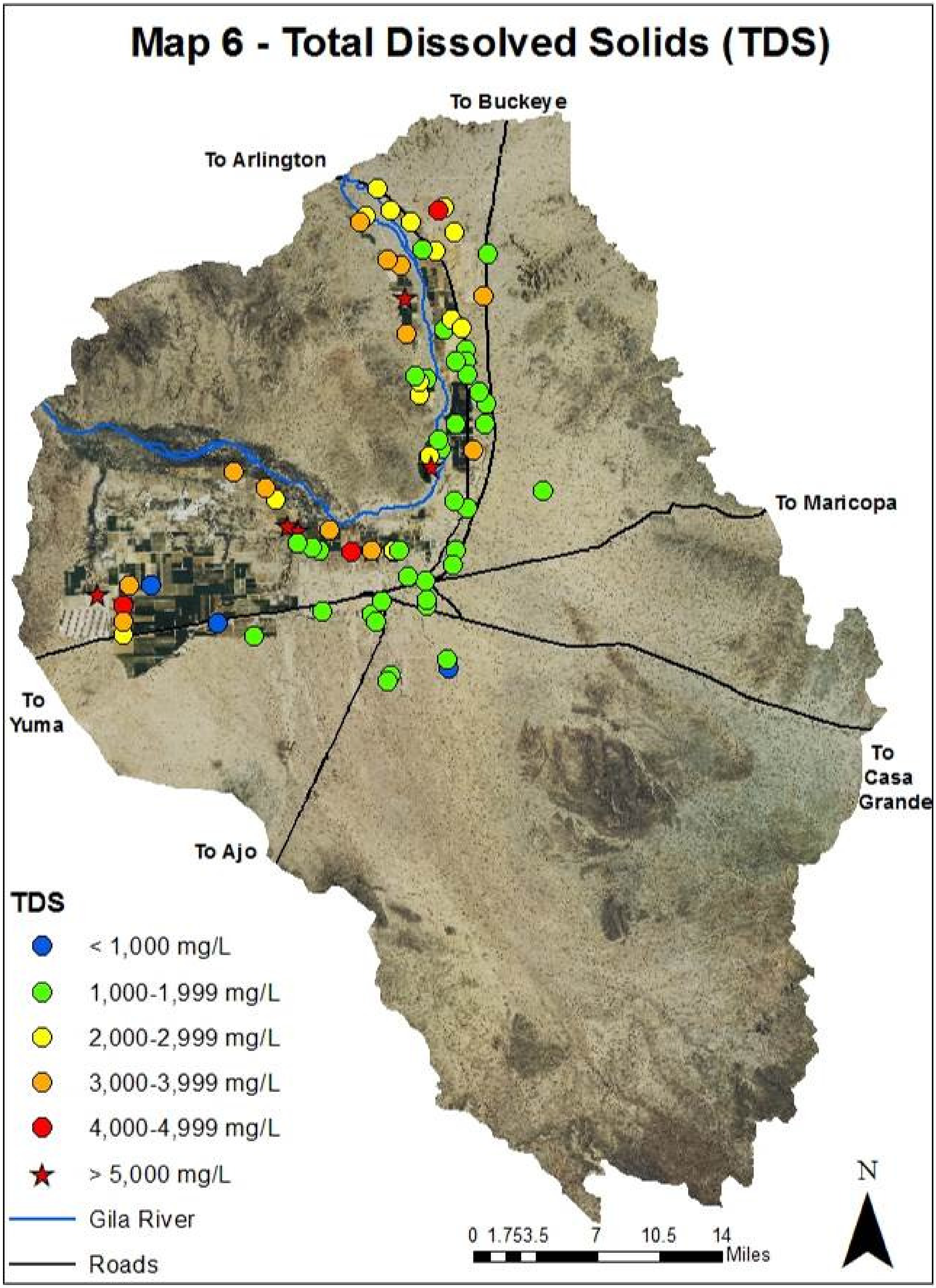
Most trace elements such as aluminum, antimony, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, thallium, and zinc were rarely – if ever - detected. Only arsenic, barium, boron, fluoride, selenium, and strontium were detected at more than 50 percent of the sites.

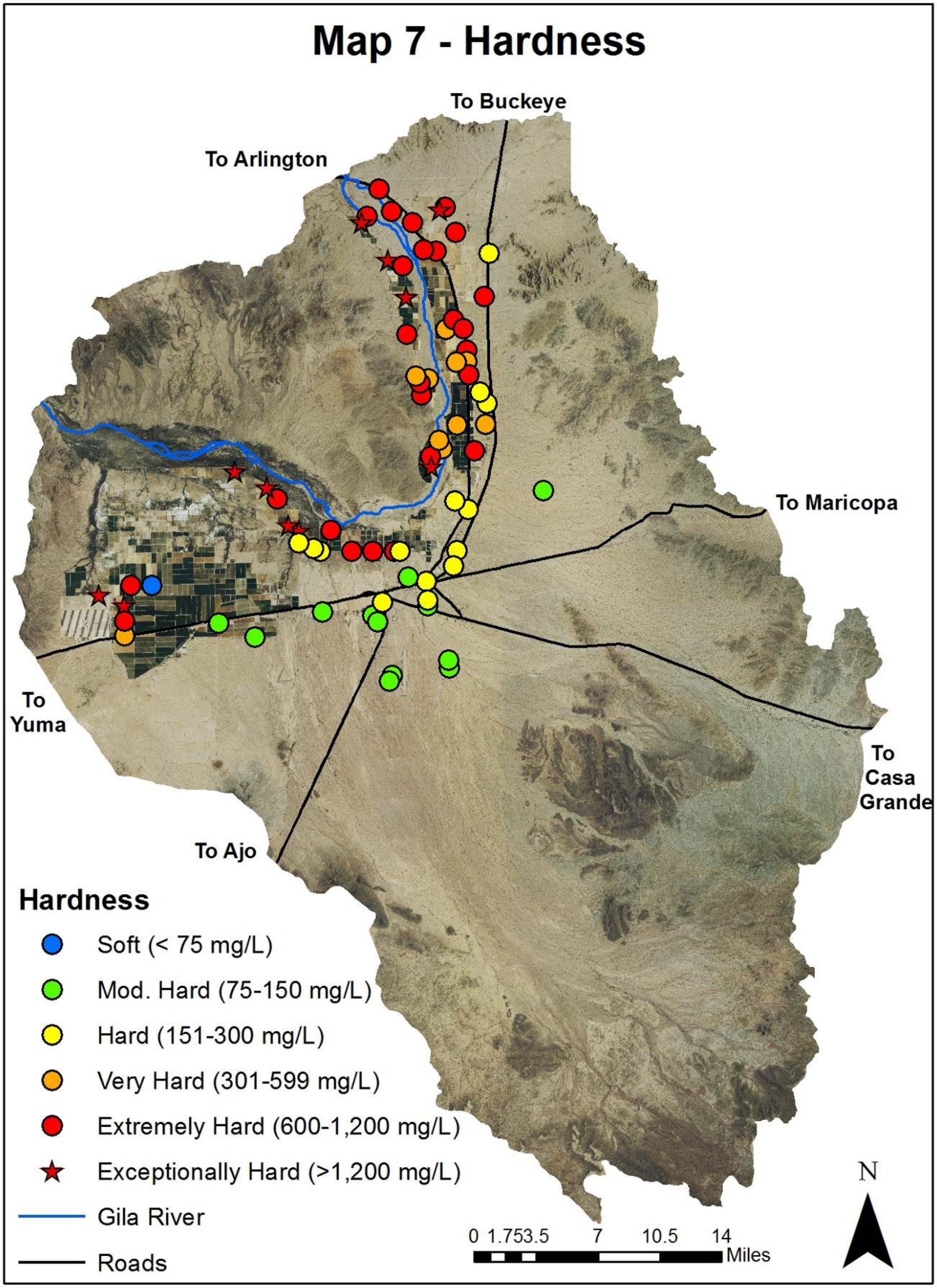
The groundwater at each sample site was assessed as to its suitability for irrigation use based on salinity and sodium hazards. Excessive levels of sodium are known to cause physical deterioration of the soil and vegetation. Irrigation water may be classified using SC and the Sodium Adsorption Ratio (SAR) in conjunction with one another.[33]

Groundwater sites in the Gila Bend basin display a narrow range of irrigation water classifications. Samples predominantly had a "medium to high" sodium hazard and a "high to very high" salinity hazard (Table 9).

Table 9. Sodium and Salinity Hazards for Sampled Sites

Hazard	Total Sites	Low	Medium	High	Very High
		Sodium Hazard			
Sodium Adsorption Ratio (SAR)		0 - 10	10- 18	18 - 26	> 26
Sample Sites	77	2	29	34	12
		Salinity Hazard			
Specific Conductivity (µS/cm)		100–250	250 – 750	750-2250	>2250
Sample Sites	77	0	0	15	62


Map 6 - Total Dissolved Solids (TDS)
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
TDS
< 1,000 mg/L
1,000-1,999 mg/L
2,000-2,999 mg/L
3,000-3,999 mg/L
4,000-4,999 mg/L
> 5,000 mg/L
Gila River
Roads
0 1.75 3.5 7 10.5 14
Miles
N



Map 7 - Hardness
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Hardness
Soft (< 75 mg/L)
Mod. Hard (75-150 mg/L)
Hard (151-300 mg/L)
Very Hard (301-599 mg/L)
Extremely Hard (600-1,200 mg/L)
Exceptionally Hard (>1,200 mg/L)
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

Constituent Co-Variation

The correlations between different chemical parameters were analyzed to determine the relationship between the constituents that were sampled. The strength of association between the chemical constituents allows for the identification of broad water quality patterns within a basin.

The results of each combination of constituents were examined for statistically-significant positive or negative correlations. A ***positive correlation*** occurs when, as the level of a constituent increases or decreases, the concentration of another constituent also correspondingly increases or decreases. A ***negative correlation*** occurs when, as the concentration of a constituent increases, the concentration of another constituent decreases, and vice-versa. A positive correlation indicates a direct relationship between constituent concentrations; a negative correlation indicates an inverse relationship.[34]

Several significant correlations occurred among the 77 sample sites (Table 10, Kendall's tau-b test, $p \leq 0.05$). Three groups of correlations were identified:

- TDS was positively correlated with hardness, strontium (Diagram 3), oxygen-18, and all the major ions (calcium, magnesium, sodium, potassium, bicarbonate, chloride, and sulfate).

- Arsenic and fluoride had a positive correlation with temperature, pH-field, and with one another. Negative correlations occurred with TDS, hardness, calcium (Diagram 4), magnesium, bicarbonate, chloride, and sulfate.

- Nitrate was positively correlated with oxygen-18 and deuterium.

TDS concentrations are best predicted among major ions by chloride concentrations (Diagram 5) (standard coefficient = 0.52), among cations by calcium concentrations (standard coefficient = 0.51) and among anions, by chloride concentrations (standard coefficient = 0.79) (multiple regression analysis, $p \leq 0.01$).

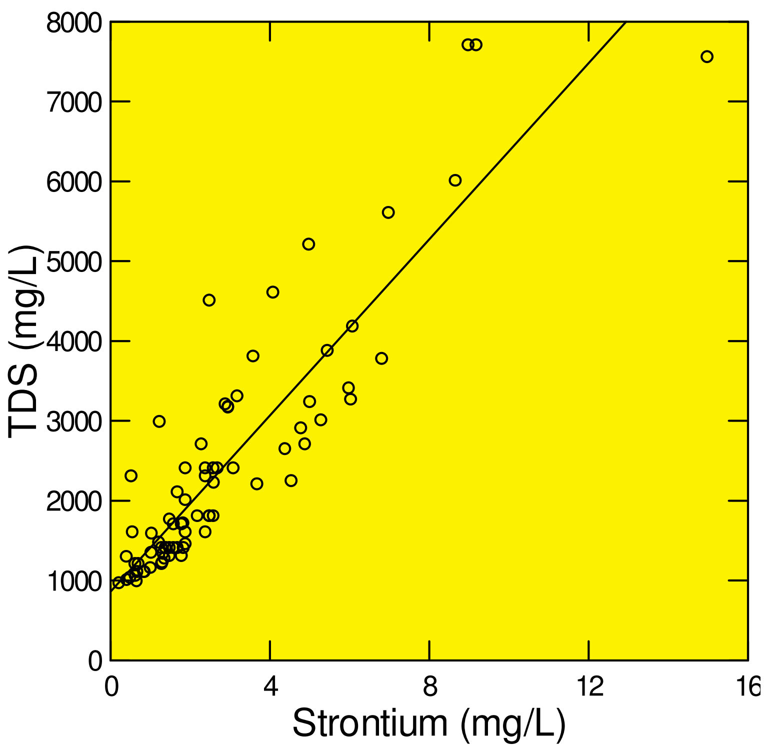


Diagram 3 – The graph illustrates a positive correlation between two constituents; as TDS concentrations increase, strontium concentrations also increase. The EPA, through an October 20, 2014 Federal Register notice, announced its preliminary regulatory determination for five unregulated contaminants including strontium. EPA used a non-cancer drinking water-based health reference level (HRL) for strontium of 1.5 mg/l as part of this regulatory determination. Currently EPA uses a lifetime health advisory level of 4 mg/l and a one-day health advisory level of 25 mg/l. [10]

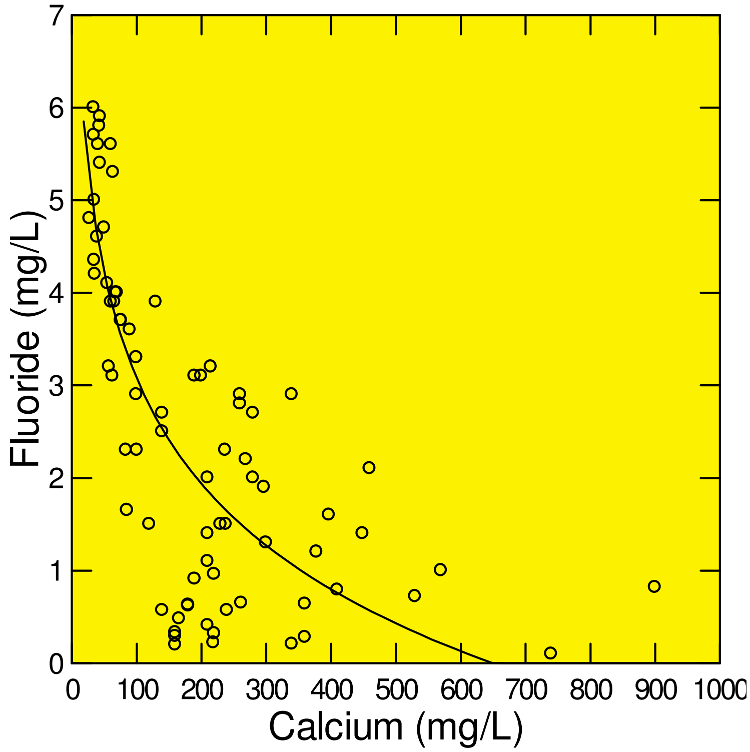


Diagram 4 – The graph illustrates a negative correlation between two constituents; as fluoride concentrations increase, calcium concentrations decrease. Calcium is an important control on elevated fluoride concentrations through precipitation of the mineral fluorite. High concentrations of fluoride had correspondingly depleted concentrations of calcium. Lower fluoride concentrations are partially controlled by hydroxyl ion exchange.[22]

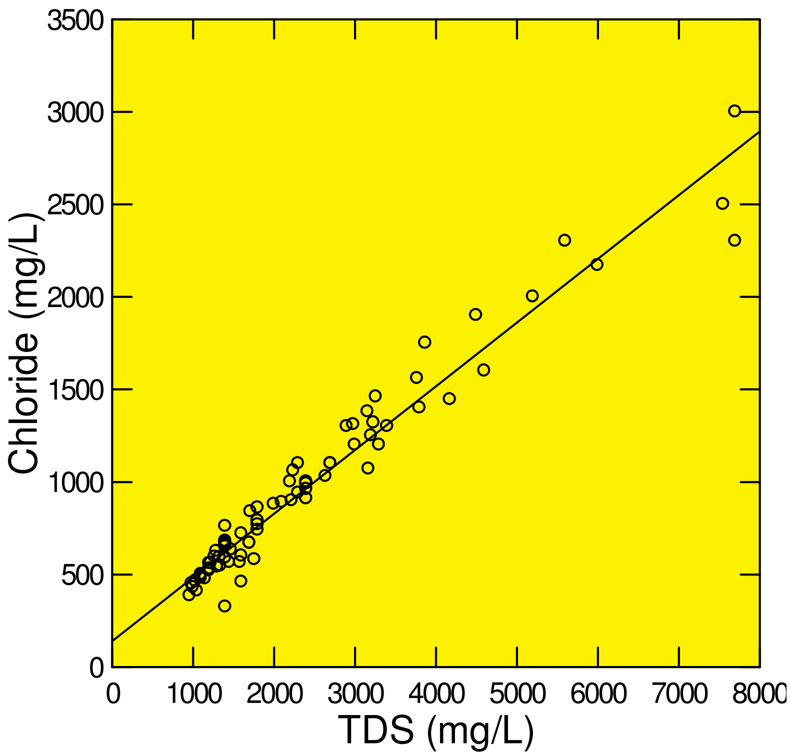


Diagram 5 – The graph illustrates a positive correlation between two constituents; as chloride concentrations increase, TDS concentrations also increase. Multiple regression analysis had determined TDS concentrations are best predicted among major ions by chloride concentrations.

Table 10. Correlation among Groundwater Quality Constituent Concentrations

Constituent	Temp	pH-f	TDS	Hard	Ca	Mg	Na	K	Bic	Cl	SO_4	NO_3	As	B	F	Sr	O-18	D
Physical Parameters																		
Temperature			++	++	++	++	++	++	++	++	++	++	**		**	++		
pH-field			++	++	++	++	++	++	++	++	++	++	**		**	++		
General Mineral Characteristics																		
TDS				**	**	**	**	**	**	**	**	**	++	*	++	**	**	
Hardness					**	**	**	**	**	**	**	**	++		++	**	**	
Major Ions																		
Calcium						**	**	**	**	**	**	**	++		++	**	**	
Magnesium							**	**	**	**	**	**	++		++	**	**	
Sodium								**	**	**	**	**		**	+	**	*	
Potassium										**	**	**				**		
Bicarbonate										**	**	*	++		++	**		++
Chloride											**	**	+	**	++	**	**	
Sulfate												**	++	**	++	**	**	
Nutrients																		
Nitrate														**	++	**	**	**
Trace Elements																		
Arsenic														**	**	++		
Boron																	**	**
Fluoride																++		
Strontium																		
Isotopes																		
Oxygen-18																		**
Deuterium																		

Blank cell = not a significant relationship between constituent concentrations

* = Significant positive relationship at $p \leq 0.05$

** = Significant positive relationship at $p \leq 0.01$

+ = Significant negative relationship at $p \leq 0.05$

++ = Significant negative relationship at $p \leq 0.01$

Oxygen and Hydrogen Isotopes

Oxygen and hydrogen isotope samples were collected from 77 sites in the Gila Bend basin. The Local Meteoric Water Line (LMWL) formed by the samples has a slope of 4.3, which is common for an arid environment. The LMWL for the Gila Bend basin is described by the linear equation:

$$\delta D = 4.3\ {}^{18}O - 28.8$$

The LMWL for the Gila Bend basin is similar to other basins in Arizona (Diagram 6): [26]

- Aravaipa Canyon - 4.1,
- Dripping Springs Wash - 4.4,
- San Rafael – 4.6,
- Upper Hassayampa - 5.0,
- Detrital Valley - 5.2,
- Agua Fria - 5.3,
- Bill Williams - 5.3,
- Meadview- 5.5,
- Sacramento Valley – 5.5,
- Tonto Basin - 5.5,
- Big Sandy - 6.1,
- Butler Valley - 6.4,
- Pinal Active Management Area – 6.4,
- Gila Valley - 6.4,
- San Simon - 6.5,
- San Bernardino Valley - 6.8,
- Harquahala - 7.1,
- McMullen Valley - 7.4,
- Lake Mohave - 7.8, and
- Ranegras Plain - 8.3.

Oxygen and deuterium isotope values at most sites in the Gila Bend basin are lighter and more depleted than would be expected from recharge occurring at elevations within the basin. This suggests that much of the groundwater was recharged long ago (8,000 to 12,000 years) during cooler climatic conditions rather than more recent precipitation or surface water recharge.[12]

Isotope values did, however, exhibit variability that allowed them to be divided into two groups. The 13 samples that experienced the most evaporation were characterized as younger, enriched water and were collected from areas associated with surface flows: along the Enterprise Canal, the floodplain near the bend of the Gila River, and the Paloma area served by the Gila Bend Canal (Map 8). Most samples (64 wells) were older recharge which reflected groundwater recharged during cooler climatic conditions (Diagram 7). [12]

Oxygen and Hydrogen Isotopes

Groundwater characterizations using oxygen and hydrogen isotope data may be made with respect to the climate and/or elevation where the water originated, residence within the aquifer, and whether or not the water was exposed to extensive evaporation prior to collection.[9] This is accomplished by comparing oxygen-18 isotopes ($\delta\ {}^{18}O$) and deuterium (δD), an isotope of hydrogen, data to the Global Meteoric Water Line (GMWL).

The GMWL is described by the linear equation:

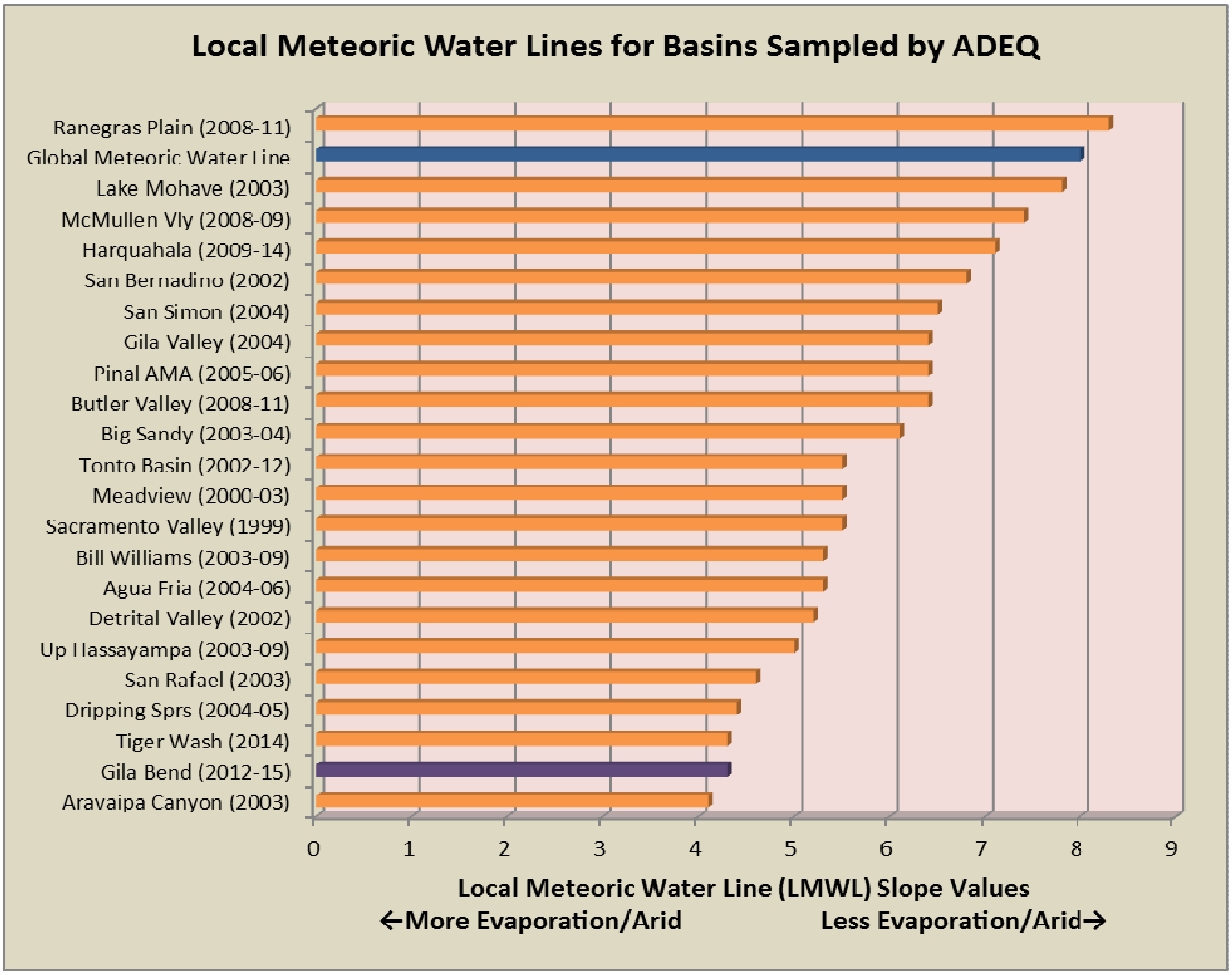
$$\delta D = 8\ \delta\ {}^{18}O + 10$$

where δD is deuterium in parts per thousand (per mil, $^0/_{00}$), 8 is the slope of the line, $\delta\ {}^{18}O$ is oxygen-18 $^0/_{00}$, and 10 is the y-intercept.[9] The GMWL is the standard by which water samples are compared and is a universal reference standard based on worldwide precipitation without the effects of evaporation.

Isotopic data from a region may be plotted to create a Local Meteoric Water Line (LMWL) which is affected by varying climatic and geographic factors. When the LMWL is compared to the GMWL, inferences may be made about the origin or history of the local water.[12] The LMWL created by $\delta\ {}^{18}O$ and δD values for samples collected at sites in the Gila Bend basin plot mostly to the right of the GMWL.

Meteoric waters exposed to evaporation are enriched and characteristically plot increasingly below and to the right of the GMWL. Evaporation tends to preferentially contain a higher percentage of lighter isotopes in the vapor phase and causes the water that remains behind to be isotopically heavier. In contrast, meteoric waters that experience little evaporation are depleted and tend to plot increasing to the left of the GMWL and are isotopically lighter.[9]

Groundwater from arid environments is typically subject to evaporation, which enriches δD and $\delta\ {}^{18}O$, resulting in a lower slope value (usually between 3 and 6) as compared to the slope of 8 associated with the GMWL.[9]



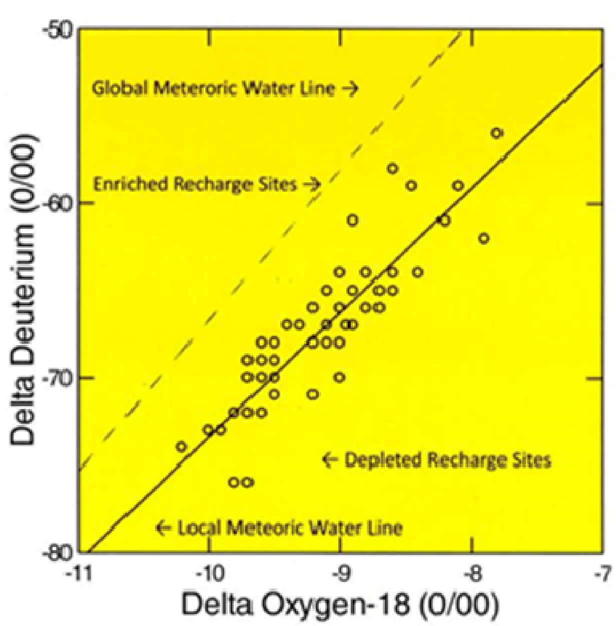
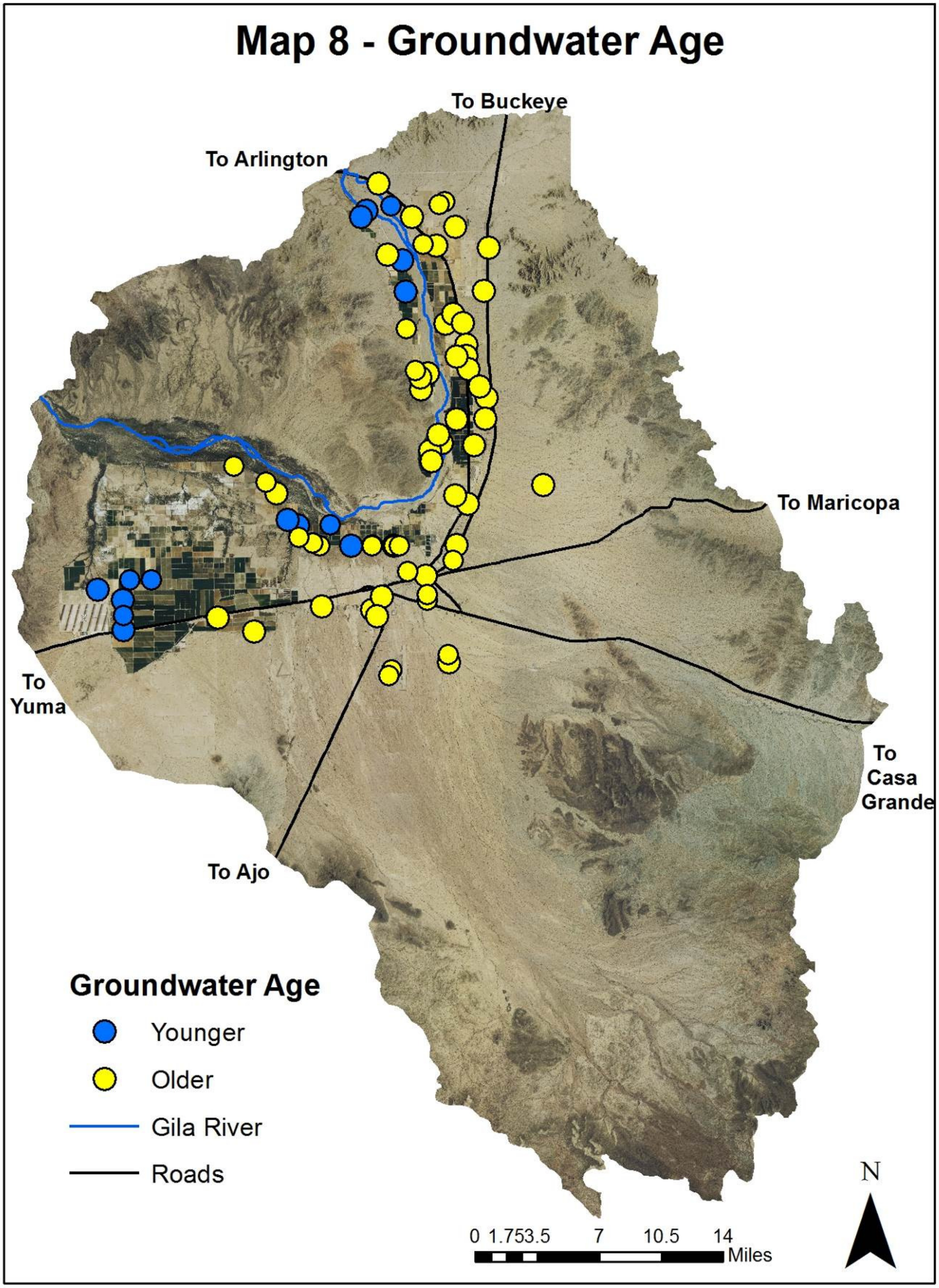


Diagram 6 – The ADEQ Ambient Monitoring Program has collected oxygen-18 and deuterium isotope samples in 22 Arizona groundwater basins. Slope values were determined for each basin's Local Meteoric Water Line, which reflects the climate and/or elevation where the water originated, residence time within the aquifer, and whether or not the water was exposed to extensive evaporation prior to collection.[11] *The slope values, which, range from 4.1 to 8.3, are reflective of groundwater in arid environments.*[12]

Diagram 7 – The 77 isotope samples are graphed according to their oxygen-18 and deuterium values and form the Local Meteoric Water Line. The most enriched samples in the basin (upper right of graph) consist of younger water that has undergone the most evaporation prior to sampling. The most depleted samples (lower left of graph) consist of older recharge from higher-elevation precipitation that has undergone less evaporation.[12]


Map 8 - Groundwater Age
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Groundwater Age
Younger
Older
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

Nitrogen Isotopes

Sources of nitrate in groundwater may be distinguished by measuring two stable isotopes of nitrogen, nitrogen-14 and nitrogen-15, often represented by $\delta^{15}N$. Although the percentage of the two isotopes is nearly constant in the atmosphere, certain chemical and physical processes preferentially utilize one isotope, causing a relative enrichment of the other isotope in the remaining reactants.

Groundwater samples for both nitrate and $\delta^{15}N$ analysis were collected at 77 wells in the basin. The nitrate values ranged from non-detect to 41.2 mg/L (Map 9) while $\delta^{15}N$ values ranged from +6.3 to +23.3 0/00 (Map 10). The relationship between nitrate concentrations and $\delta^{15}N$ values is shown in Diagram 8.

Because of these isotopic fractionation processes, nitrate from different nitrogen sources has been shown to have different N isotope ratios. The $\delta^{15}N$ values have been cited as ranging from +2 to +9 per mil for natural soil organic matter sources, -3 to +3 for inorganic fertilizer sources, +10 to +20 per mil for animal waste. [24]

Nitrogen-15 results in the basin fall into the following categories:

- No signal: 1 site,
- Fertilizer (-3 to +3): 0 sites,
- Organic soil matter (+2 to +9): 15 sites,
- Mixture (+9 to +10): 12 sites,
- Animal waste (+10 to +20): 46 sites,
- Indeterminate (> +20): 3 sites

Based on these results, it appears that the nitrogen source is predominantly animal waste with organic soil matter impacting about a third of the sites.[24] Animal waste as a nitrogen source appears to be especially predominant in the Cotton Center and Enterprise areas.

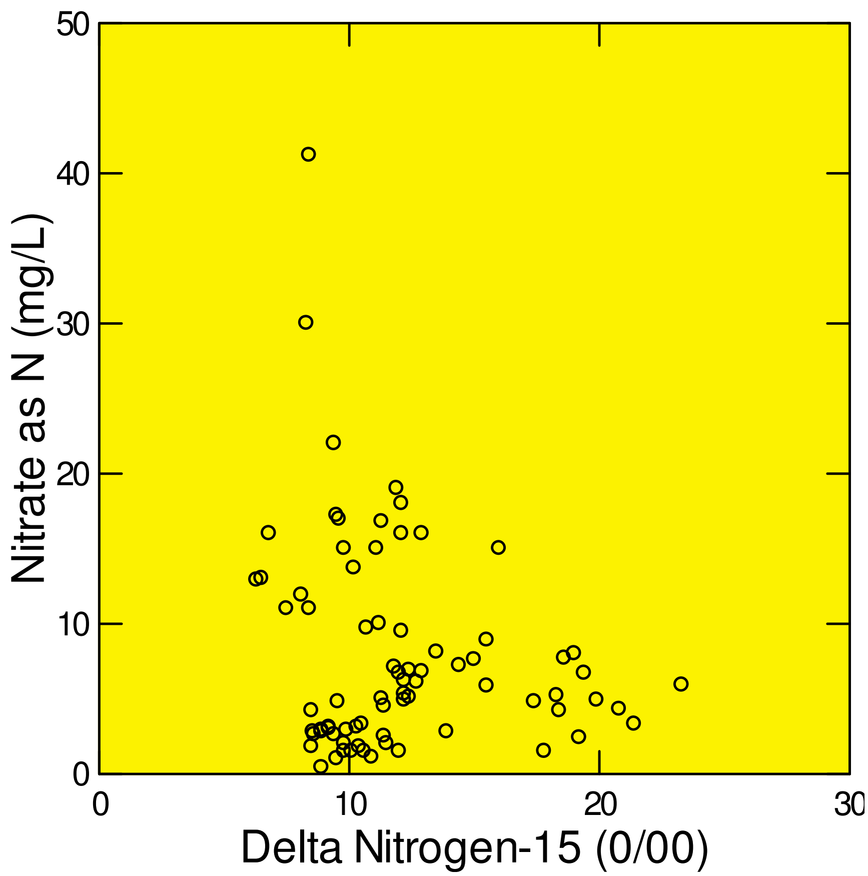
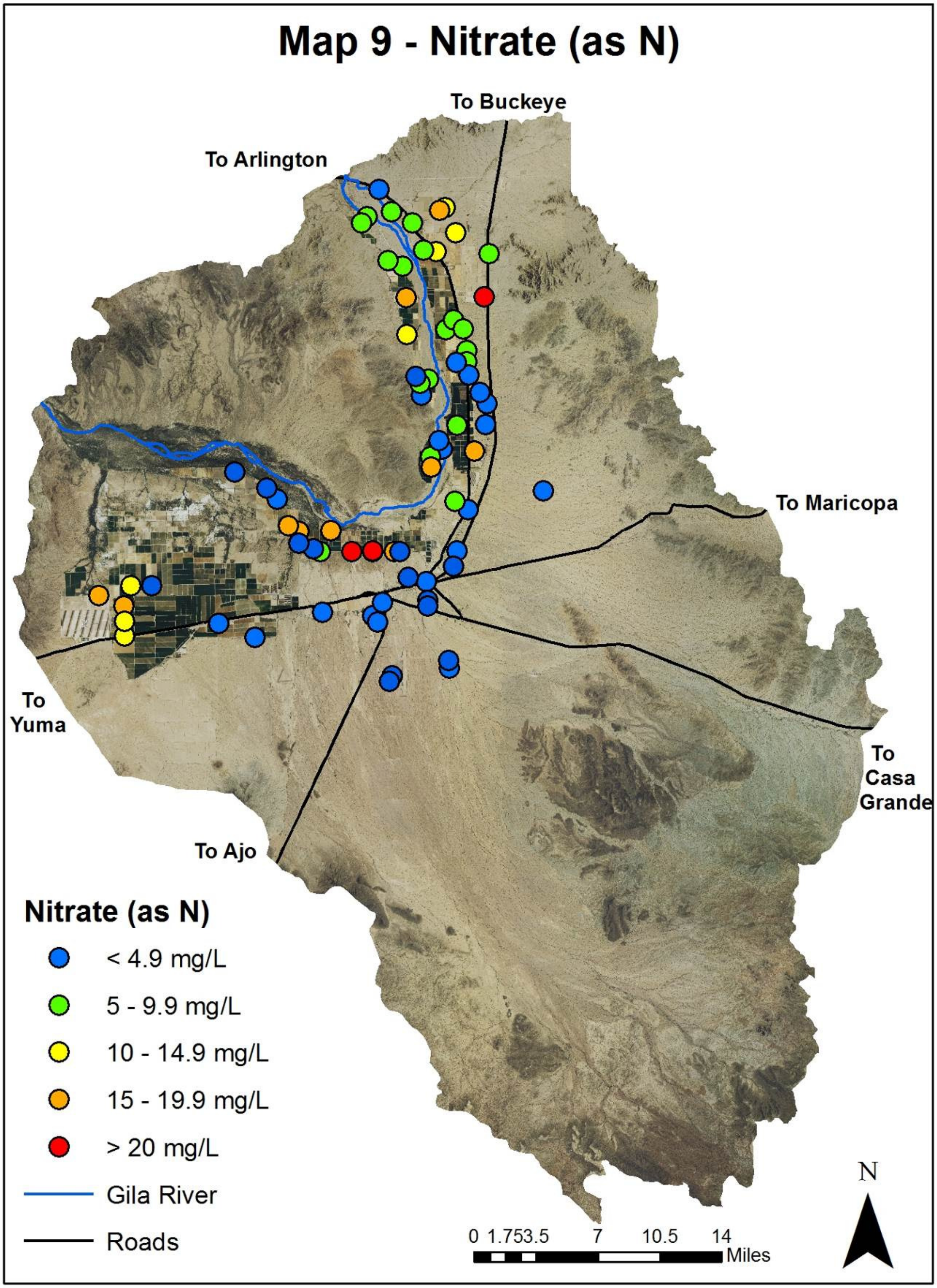
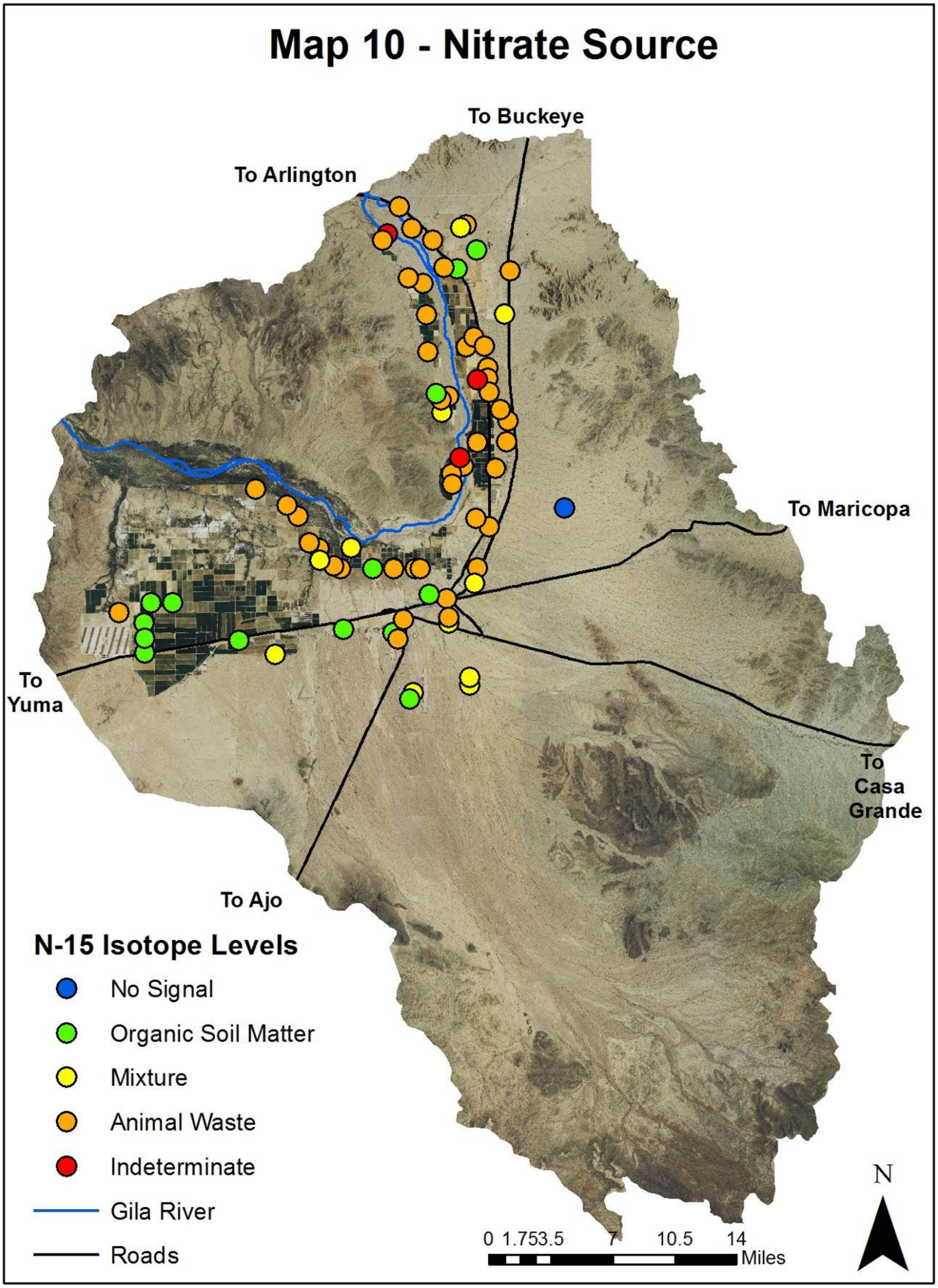


Diagram 8 – The graph illustrates the relationship between $\delta^{15}N$ values and nitrate (as nitrogen) concentrations in the 77 wells at which nitrogen isotope samples were collected. Most $\delta^{15}N$ values are above +10 per mil which corresponds to the range commonly associated with animal waste.[24]



Map 9 - Nitrate (as N)
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Nitrate (as N)
< 4.9 mg/L
5 - 9.9 mg/L
10 - 14.9 mg/L
15 - 19.9 mg/L
> 20 mg/L
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N



Map 10 - Nitrate Source
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
N-15 Isotope Levels
No Signal
Organic Soil Matter
Mixture
Animal Waste
Indeterminate
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

Groundwater Quality Variation

Among Five Hydrologic Groups – Twenty-six (26) groundwater quality constituents were compared between five broad hydrologic groups (Map 11):

- Cotton Center (CC) – 30 sample sites north of Gila Bend where farmland is irrigated with only groundwater;
- Enterprise (E) – six sample sites where farmland is irrigated with a mix of groundwater and Gila River water through the Enterprise Canal;
- Gila Bend (GB) – 17 sample sites Gila Bend of irrigated agriculture predominantly in the Gila Bend area;
- Painted Rock (PR) – 16 sample sites west of Gila Bend located near the Gila River where farmland is irrigated with only groundwater and;
- Paloma (P) – eight sites where farmland is irrigated with a mix of groundwater and Gila River water through the Gila Bend Canal.

Significant concentration differences were found with 22 constituents: oxygen-18 (Diagram 9), and deuterium, temperature, pH-field (Diagram 10), pH-lab, SC-field, SC-lab, TDS, hardness, calcium, magnesium, sodium, potassium, bicarbonate, chloride, sulfate, nitrate, $\delta^{15}N$, arsenic (Diagram 11), boron, fluoride, and strontium, (Kruskal-Wallis and Tukey tests, $p \leq 0.05$).

Complete statistical results are in Table 11 and 95 percent confidence intervals for significantly different land use groups are in Table 12.

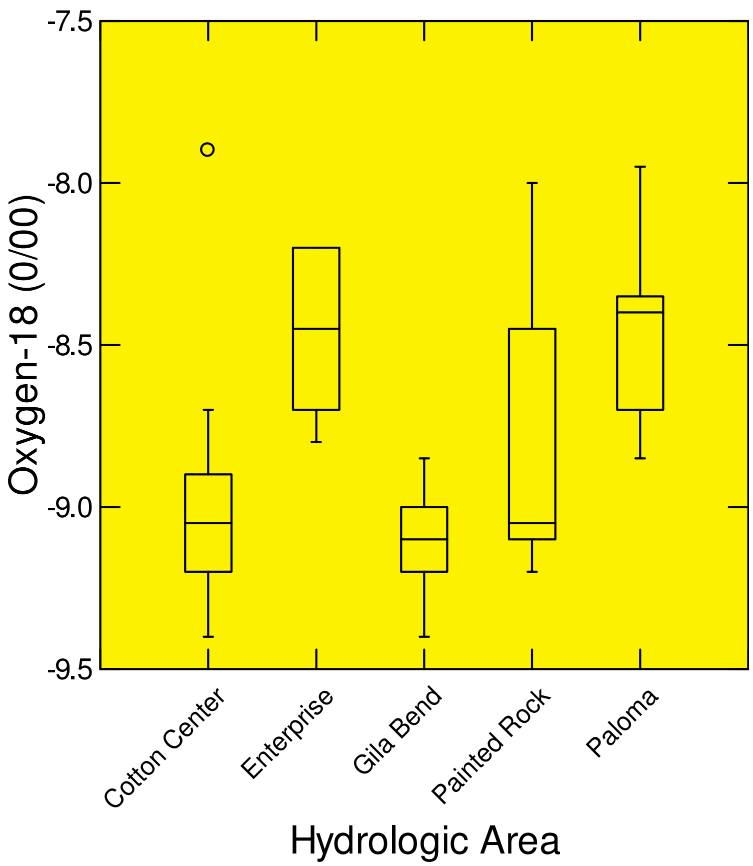


Diagram 9 – Samples collected from wells in the Paloma and Enterprise areas have significantly higher oxygen-18 values than samples collected from wells in other hydrologic areas (Kruskal-Wallis and Tukey tests, $p \leq 0.01$). These differences are likely related to the irrigation source used in these areas which include surface water from the Gila River. The slightly higher value of Painted Rock than either the Cotton Center or Gila Bend hydrologic group is like due to considerable surface water recharge that occurs in this area when floodwaters are impounded by Painted Rock Dam.

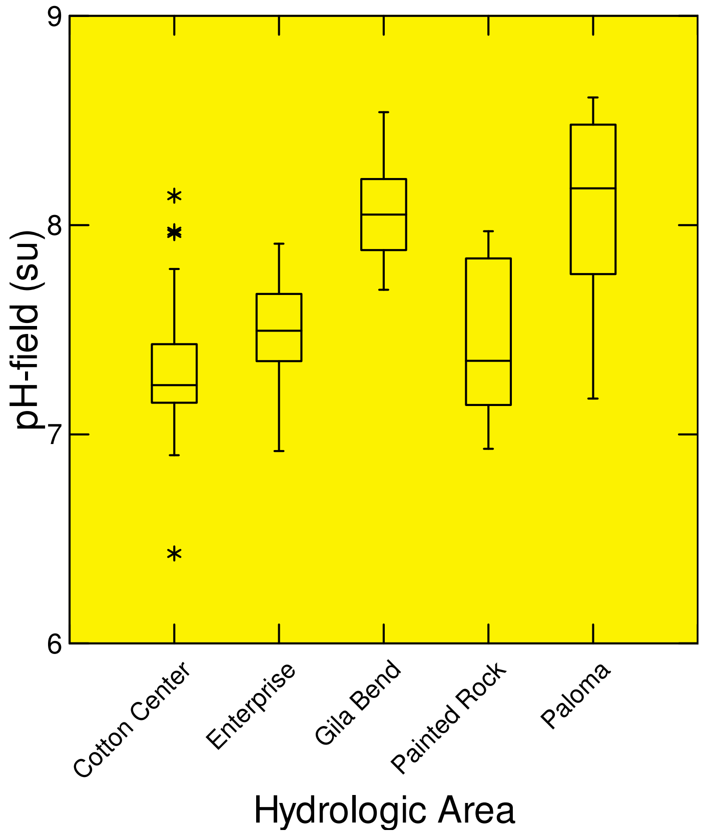


Diagram 10 – Samples collected from wells in the Gila Bend and Paloma areas had significantly higher pH-field levels than samples collected from other hydrologic areas (Kruskal-Wallis and Tukey tests, $p \leq 0.01$). Elevated pH levels may occur through long residence time in the aquifer or from silicate hydrolysis reactions as recharged groundwater moves downgradient.[22]

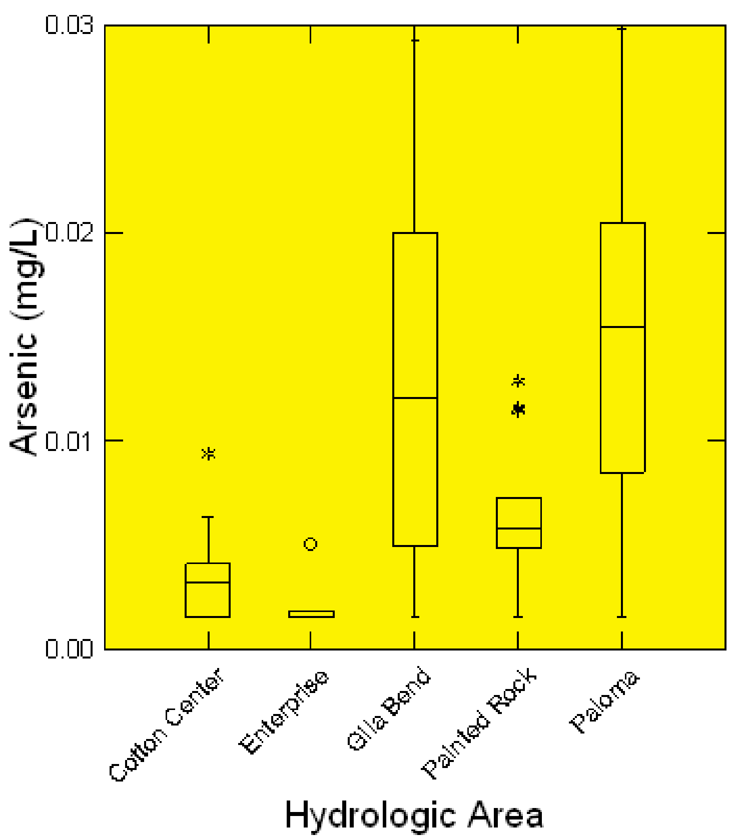


Diagram 11 – Samples collected from wells in the Gila Bend and Paloma areas had significantly higher arsenic concentrations than samples collected from other hydrologic areas (Kruskal-Wallis and Tukey tests, $p \leq 0.01$). Arsenic concentrations are impacted by aquifer residence time as well as other factors such as lithology, an oxidizing environment, and reactions including exchange on clays or with hydroxyl ions.[22]

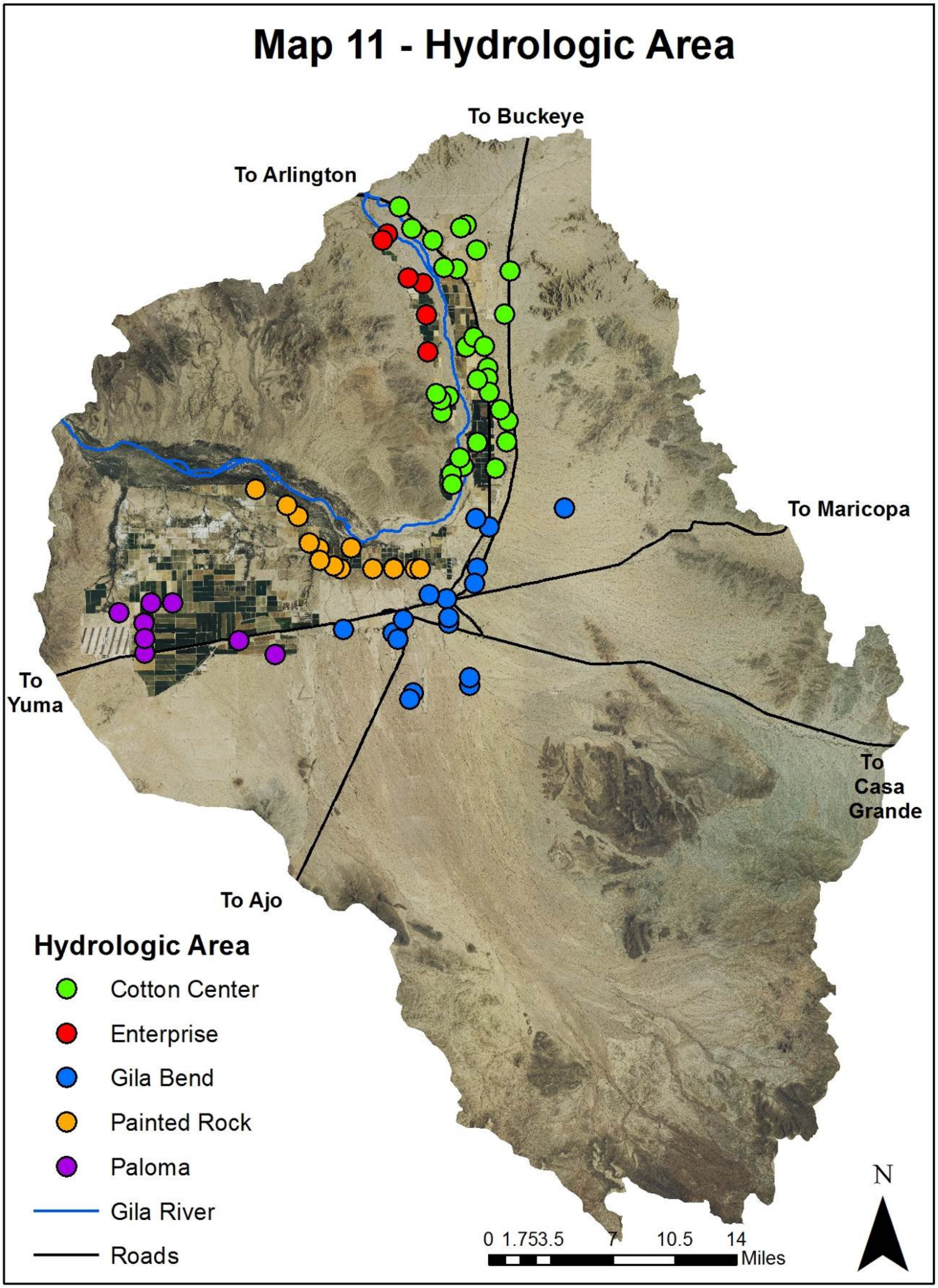

Map 11 - Hydrologic Area
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Hydrologic Area
Cotton Center
Enterprise
Gila Bend
Painted Rock
Paloma
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

Table 11. Variation in Groundwater Quality Constituent Concentrations among Five Hydrologic Areas

Constituent	Sites Sampled	Significance	Significant Differences Between Cotton Center (CC), Enterprise (E), Gila Bend (GB), Painted Rock (PR), and Paloma (P)
Oxygen	77	**	E & P > CC & GB** P > PR *
Deuterium	77	**	P > CC, GB & PR** E > CC *
Temperature - field	77	**	GB & P > E, CC, & PR** CC & PR > E*
pH – field	77	**	GB & P > E, CC, & PR**
pH – lab	77	**	GB & P > E, CC, & PR**
SC - field	77	**	E & PR > GB ** P > GB, PR > CC*
SC - lab	77	**	E & PR > GB ** P > GB, PR > CC*
TDS	77	**	E & PR > GB ** P > GB, E > CC*
Hardness	77	**	E > GB & CC, PR > GB, CC > GB ** E > P*
Calcium	77	**	E & PR > GB ** CC & P > GB *
Magnesium	77	**	E > CC, GB, P & PR CC & PR > GB **
Sodium	77	**	P & PR > GB *
Potassium	77	**	PR > GB & P**
Bicarbonate	69	**	E > CC, GB, P & PR, CC & PR > GB & P**
Chloride	77	**	E & PR > GB, PR > CC** P > GB *
Sulfate	77	**	P & PR > GB ** E > GB *
Nitrate (as N)	77	**	PR > GB ** PR > CC*
$\delta^{15}N$	76	**	E > GB, P & PR** CC > GB & P**
Arsenic	77	**	GB & P > E, CC & PR**
Barium	77	**	-
Boron	77	**	P > E, GB & CC, PR > CC** PR > GB *
Fluoride	77	**	GB & P > E & CC, GB > PR, PR > E
Selenium	77	*	-
Strontium	77	**	PR > GB **
Radon	51	ns	-
Uranium	17	*	-

ns = not significant
* = significant at $p \leq 0.05$ or 95% confidence level
** = significant at $p \leq 0.01$ or 99% confidence level

Table 12. Summary Statistics for Five Hydrologic Areas with Significant Constituent Differences

Constituent	Significance	Cotton Center (CC)	Enterprise (E)	Gila Bend (GB)	Painted Rock (PR)	Paloma (P)
Oxygen	**	-9.12 to 8.91	-8.73 to -8.20	-9.17 to -9.01	-9.04 to-8.62	-8.70 to -8.22
Deuterium	**	-68.0 to -67.0	-67.0 to-64.1	-67.3 to -66.1	-68.5 to-65.9	- 65.2 to -63.2
Temperature - field	**	25.9 to 28.3	21.6 to 24.6	28.4 to 33.0	26.0 to 28.4	30.8 to 32.6
pH – field	**	7.20 to 7.45	7.12 to 7.83	7.92 to 8.19	7.26 to 7.65	7.66 to 8.50
pH – lab	**	7.37 to 7.51	7.01 to 7.57	7.97 to 8.16	7.37 to 7.72	7.85 to 8.61
SC - field	**	2810 to 3681	3641 to 6113	2031 to 2294	3401 to 6185	1989 to 6509
SC - lab	**	2924 to 3862	3969 to 5948	1971 to 2288	3583 to 6385	2003 to 6840
TDS	**	1832 to 2541	1933 to 5924	1153 to 1303	2314 to 4257	1179 to 4859
Hardness	**	548 to 804	661 to 2163	125 to 167	444 to 1088	-96 to 1447
Calcium	**	162 to 232	175 to 576	45 to 61	180 to 425	23 to 515
Magnesium	**	33 to 56	54 to 177	2 to 5	22 to 77	-11 to 46
Sodium	**	-	-	347 to 401	430 to 876	378 to 1051
Potassium	**	-	-	4.4 to 11.6	11.4 to 14.8	2.5 to 11.2
Bicarbonate	**	160 to 192	182 to 337	64 to 93	123 to 215	14 to 87
Chloride	**	-	870 to 1870	493 to 607	999 to1721	539 to 1752
Sulfate	**	285 to 439	487 to 876	138 to 163	297 to 837	55 to 1338
Nitrate (as N)	**	5.4 to 9.1	-	1.8 to 3.5	6.9 to 18.6	-
$\delta^{15}N$		12.2 to 15.1	13.1 to 21.4	9.3 to 10.5	9.9 to 12.7	6.9 to 9.9
Arsenic	**	0.003 to 0.004	0.001 to 0.004	0.008 to 0.017	0.005 to 0.008	0.007 to 0.023
Barium	**	-	-	-	-	-
Boron	**	0.62 to 1.01	0.51 to 1.6	0.85 to 1.04	1.03 to 2.56	1.81 to 3.31
Fluoride	**	1.1 to 2.1	0.1 to 0.8	4.0 to 5.0	1.8 to 3.0	1.8 to 4.8
Selenium	**	-	-	-	-	-
Strontium	**	-	-	0.8 to 1.3	3.0 to 5.7	-
Radon	ns	-	-	-	-	-
Uranium	*	-	-	-	-	-

ns = not significant
* = significant at $p \leq 0.05$ or 95% confidence level
** = significant at $p \leq 0.01$ or 99% confidence level
All units are mg/L except where indicated.

Between Two Recharge Groups – Twenty-six groundwater quality constituents were compared between two recharge types: younger (13 sites), and older (64 sites) (Map8).[12]

Significant concentration differences were found with 16 constituents: oxygen-18 (Diagram 12), deuterium, SC-field, SC-lab, TDS, hardness (Diagram 13), calcium, magnesium, sodium, chloride, sulfate, nitrate, boron, copper, selenium, and strontium (Kruskal-Wallis test, $p \leq 0.05$).

Complete statistical results are in Table 13 and 95 percent confidence intervals for significantly different groups based on recharge groups are in Table 14.

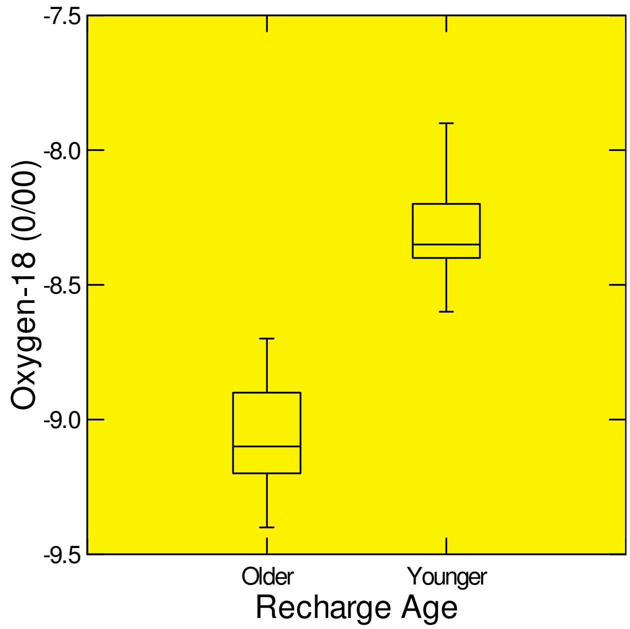


Diagram 12 – Samples collected from sites having younger recharge have significantly higher oxygen-18 values than from sites having older recharge (Kruskal-Wallis test, $p \leq 0.01$). The younger sites consist of a combination of sampled wells that have received recent recharge from the Gila River through irrigation applications from the Enterprise Canal or Gila Bend Canal or from floodwaters of the Gila River. The older sites appear to consist of groundwater recharged long ago (8,000 to 12,000 years) during cooler climatic conditions.[12]

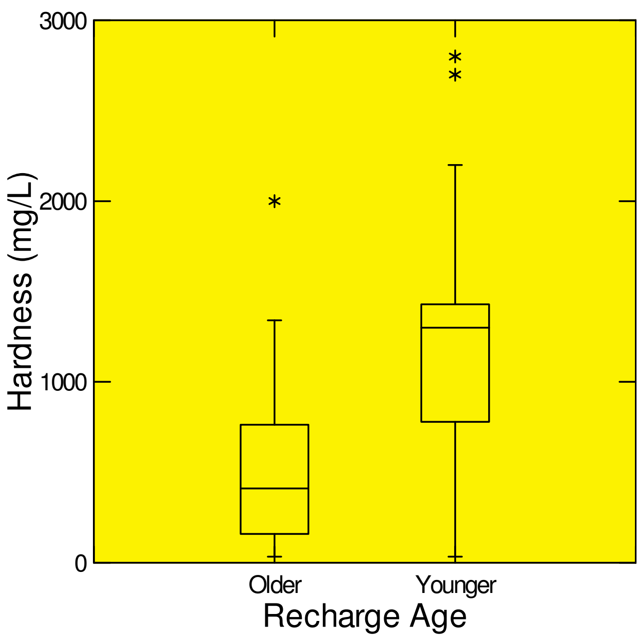


Diagram 13 – Samples collected from sites having younger recharge have significantly higher hardness concentrations than from sites having older recharge (Kruskal-Wallis test, $p \leq 0.01$). Elevated hardness concentrations are often associated with recent recharge while groundwater with a long aquifer residence time typically evolves into a softer, sodium-dominated chemistry.[22]

Table 13. Variation in Groundwater Quality Constituent Concentrations Between Two Recharge Groups

Constituent	Sites Sampled	Significance	Significant Differences Between Two Recharge Groups
Temperature - field	77	ns	-
pH – field	77	ns	-
pH – lab	77	ns	-
SC - field	77	**	Younger > Older
SC - lab	77	**	Younger > Older
TDS	77	**	Younger > Older
Hardness	77	**	Younger > Older
Calcium	77	**	Younger > Older
Magnesium	77	**	Younger > Older
Sodium	77	**	Younger > Older
Potassium	77	ns	-
Bicarbonate	69	ns	-
Chloride	77	**	Younger > Older
Sulfate	77	**	Younger > Older
Nitrate (as N)	77	**	Younger > Older
$\delta^{15}N$	76	ns	-
Arsenic	77	ns	-
Barium	77	ns	-
Boron	77	**	Younger > Older
Chromium	77	ns	-
Copper	77	ns	-
Fluoride	77	ns	-
Selenium	77	**	Younger > Older
Strontium	77	**	Younger > Older
Radon	51	ns	-
Oxygen	77	**	Younger > Older
Deuterium	77	**	Younger > Older

ns = not significant
* = significant at $p \leq 0.05$ or 95% confidence level
** = significant at $p \leq 0.01$ or 99% confidence level

Table 14. Summary Statistics for Two Recharge Groups with Significant Constituent Differences

Constituent	Significance	Younger	Older
Temperature - field	ns	-	-
pH – field	ns	-	-
pH – lab	ns	-	-
SC - field	**	4921 to 7811	2701 to 3278
SC - lab	**	4998 to 7979	2784 to 3419
TDS	**	3374 to 5874	1744 to 2214
Hardness	**	794 to 1803	400 to 601
Calcium	**	291 to 613	130 to 188
Magnesium	**	39.8 to 123.8	22.4 to 39.0
Sodium	**	488 to 1084	421 to 508
Potassium	ns	-	-
Bicarbonate	ns	-	-
Chloride	**	1350 to 2120	727 to 914
Sulfate	**	652 to 1367	248 to 347
Nitrate (as N)	**	10.3 to 22.2	4.8 to 7.3
$\delta^{15}N$	ns	-	-
Arsenic	ns	-	-
Barium	ns	-	-
Boron	**	1.85 to 3.57	0.83 to 1.07
Chromium	ns	-	-
Copper	ns	-	-
Fluoride	ns	-	-
Selenium	**	0.01 to 0.02	-0.01 to 0.04
Strontium	**	2.58 to 7.63	1.94 to 2.81
Radon	ns	-	-
Oxygen	**	-8.37 to -8.13	-9.08 to -8.97
Deuterium	**	-64.3 to -63.2	-67.7 to -67.0

ns = not significant
* = significant at $p \leq 0.05$ or 95% confidence level
** = significant at $p \leq 0.01$ or 99% confidence level
All units are mg/L except where indicated.

DISCUSSION

Groundwater in the Gila Bend basin is generally unsuitable for drinking water uses without proper treatment based on the sampling results from this study. However, the quality of water is generally suitable for irrigation use, which is the predominant water use in the basin.

These results generally substantiate earlier water quality studies in the basin. In ADWR's water atlas, using historical data, the agency identified 122 wells in the basin with constituent concentrations exceeding health-based Primary MCLs.[5] The majority of these exceedances, 92 percent, were for fluoride. Other constituents exceeding Primary MCLs were for arsenic and nitrate along with mercury and selenium at one site apiece.

Arsenic, fluoride, nitrate, and uranium concentrations were above Primary MCLs in this ADEQ study, and are the four most common groundwater contaminants throughout the state.[27] Nitrate exceedances tended to occur in younger groundwater. Arsenic and fluoride exceedances often occurred at the same sample sites, which consisted of older groundwater. The ADEQ study, however, did not detect mercury and selenium concentrations above Primary MCLs. Based on these results it is likely that the lone mercury and selenium exceedances were caused by sample contamination or lab error. Constituents that exceeded Primary MCLs in the ADEQ study will be discussed below.

Nitrate - Nitrate exceeded health-based, water quality standards in samples collected from 21 wells. Nitrate concentrations were as high as 41.2 mg/L, which is four times the 10.0 mg/L nitrate (as nitrogen) standard.

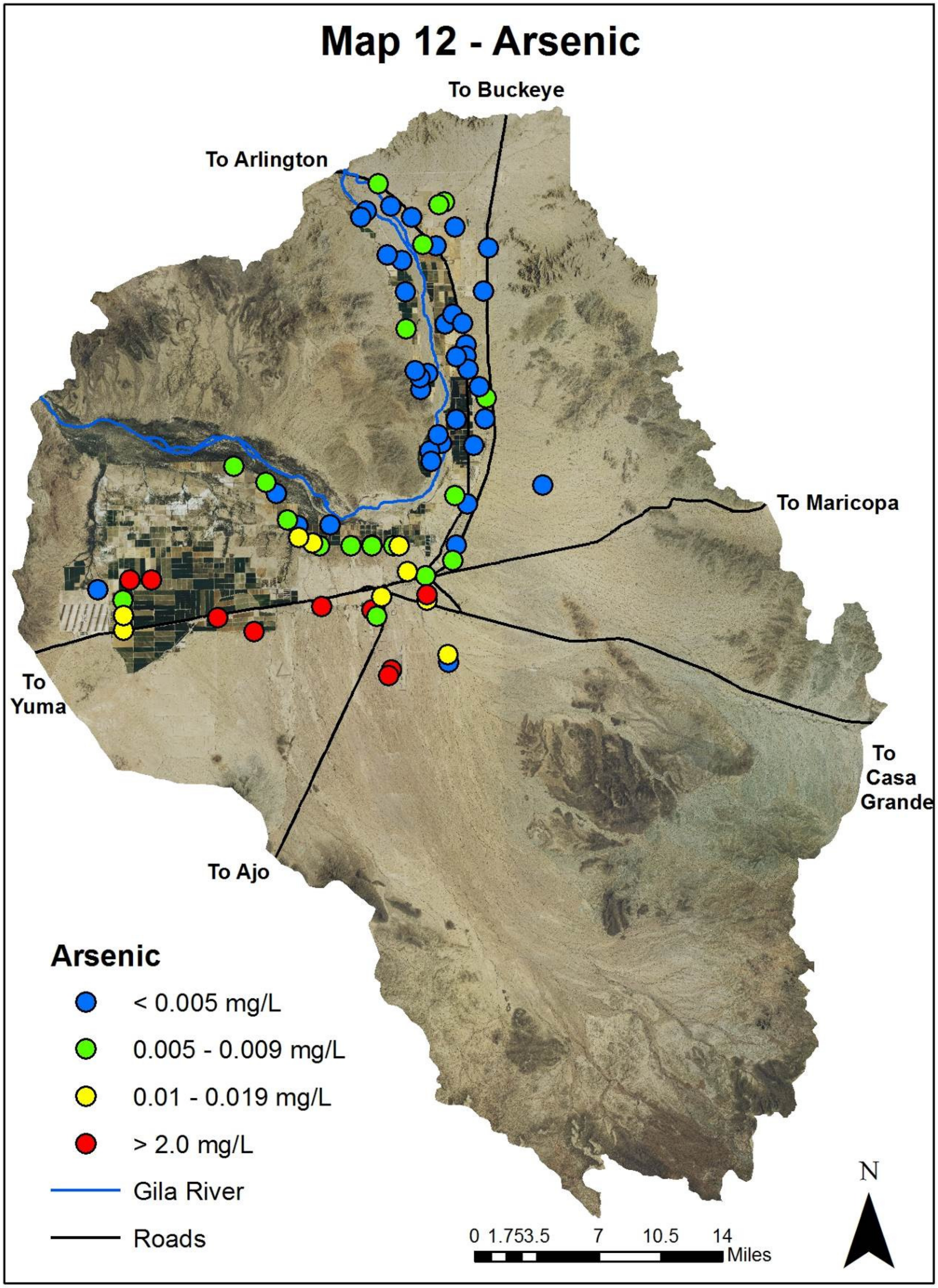
Nitrogen isotopes suggest the predominant source of nitrate is animal waste with lesser contributions from naturally occurring soil organic matter.[24] The source of the animal waste is likely the manure from the many dairy operations located in the basin used for fertilizing agricultural crops. Percolating groundwater such as which occurs underneath irrigated fields likely helps transport the nitrogen. This theory is supported by nitrate concentrations that are significantly greater in recently-recharged, younger groundwater. Nitrate cconcentrations will likely increase in the future as groundwater percolates downward and reaches depths where irrigation wells are perforated.

Nitrate concentrations tend to be lowest in the Gila Bend area of the basin and highest in the Painted Rock area (Map 9).

Arsenic - Arsenic exceeded health-based, water quality standards in samples collected from 18 wells, with concentrations as high as 0.0298 mg/L, almost three times the 0.01 mg/L standard.

Arsenic concentrations are affected by reactions with hydroxyl ions and are influenced by factors such as an oxidizing environment, lithology, and aquifer residence time.[22] These factors are present in the basin to produce elevated arsenic concentrations, especially aquifer residence time as oxygen and hydrogen isotope values suggest that groundwater was recharged long ago during cooler climatic conditions.[12] Arsenic concentrations tend to be highest in the Gila Bend (Figure 9) and Paloma areas of the basin (Map 12).

Figure 9 – ADEQ's Elizabeth Boettcher collects a sample (GIL-19) from a well supplementing flow in the Gila Bend Canal. The well is located in the Gila Bend hydrologic area, which is located upgradient of irrigated fields. It was characterized by elevated pH levels and higher concentrations of arsenic and fluoride.



Map 12 - Arsenic
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Arsenic
< 0.005 mg/L
0.005 - 0.009 mg/L
0.01 - 0.019 mg/L
> 2.0 mg/L
Gila River
Roads
0 1.753.5 7 10.5 14
Miles
N

Fluoride - Fluoride exceeded the 4.0 mg/L health-based, water quality standards in samples collected from 17 wells, with concentrations as high as 6.0 mg/L. The frequency of fluoride exceedances in this study is much less than that cited in previous reports. In 115 samples collected by ADWR in the basin between 1984 and 1989, 113 (92 percent) exceeded the 4.0 mg/L Primary MCL.[5] This high frequency may be due to older studies using 1.4 mg/L as the health-based water quality standard, based partially on an outdated method that factors in the annual average maximum daily air temperature.[19]

Fluoride concentrations in groundwater are often controlled by calcium through precipitation or dissolution of the mineral fluorite. In a chemically closed hydrologic system, calcium is removed from solution by precipitation of calcium carbonate and the formation of smectite clays. Concentrations exceeding 5 mg/L of dissolved fluoride may occur in groundwater depleted in calcium if a source of fluoride ions is available for dissolution.[22]

Sites only partially depleted in calcium may be controlled by processes other than fluorite dissolution. Hydroxyl ion exchange or sorption-desorption reactions have also been cited as providing controls on lower (< 5 mg/L) levels of fluoride. As pH values increase downgradient, greater levels of hydroxyl ions may affect an exchange of hydroxyl for fluoride ions thereby increasing fluoride in solution. [22]

Fluoride concentrations, which had a similar pattern to arsenic concentrations, tended to be highest in the Gila Bend and Paloma areas and lowest in the Enterprise area of the basin (Map 13).

Uranium - Of the 19 radionuclide samples collected, uranium exceeded health-based, water quality standards at three sites.

Two of the sites with uranium exceedances (GIL-34/35 and GIL-64) were shallow domestic wells located in irrigated areas. The elevated uranium concentrations in these wells is likely linked to the recharge of high alkalinity water, which liberates naturally occurring uranium that is absorbed to aquifer sediments.[16]

The other uranium exceedance (GIL-80/81) was likely related in the granitic geology of the nearby Buckeye Hills to the north. Granitic geology is associated with elevated radionuclide concentrations in groundwater.[17, 20]

TDS – All of the 77 sample sites exceeded the Secondary MCL of 500 mg/L. Previous studies estimating TDS concentrations from specific conductivity had similar results. Of the 118 samples analyzed between 1984 and 1989, 102 samples (or 86 percent) exceeded the Secondary MCL.[5] TDS concentrations tend to be highest in the Enterprise and Painted Rock areas and lowest in the Gila Bend area of the basin (Map 6).

Groundwater Trends - The basin's essential groundwater quality characteristics of elevated TDS concentrations, sodium-chloride chemistry, and lower fluoride concentrations north of Gila Bend were first documented in 1946.[19] Historic concentrations for arsenic, nitrate, and uranium are unknown since only limited sampling for these constituents has been conducted in the basin.

Figure 10 – ADEQ's Jade Dickens collects a sample (GIL-37) from an irrigation well located in the Painted Rock area. This farming area is located in the Gila River's floodplain after the waterway "bends" west, was characterized by higher concentrations of TDS and many major ions.

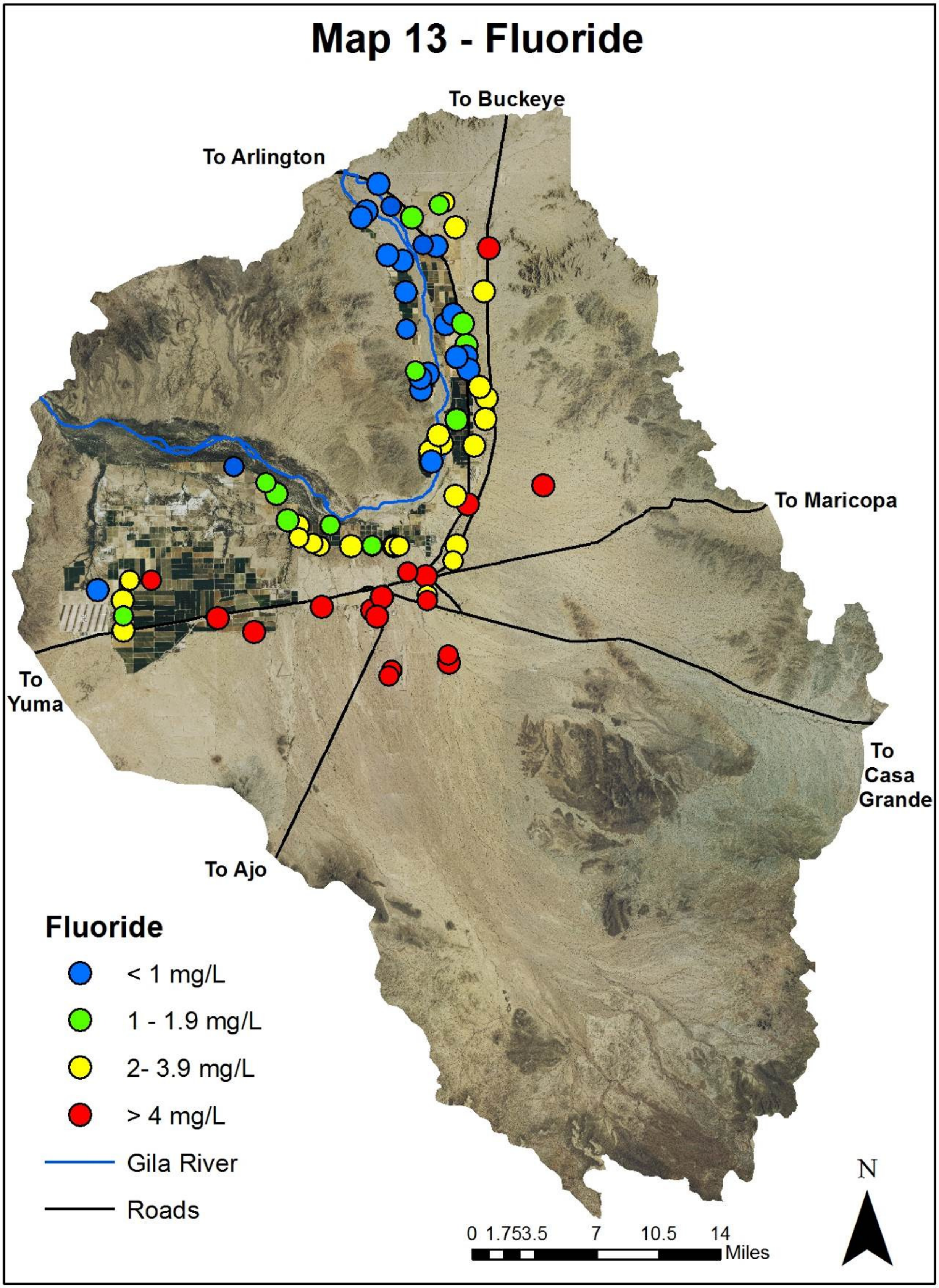

Map 13 - Fluoride
To Buckeye
To Arlington
To Maricopa
To Yuma
To Casa Grande
To Ajo
Fluoride
< 1 mg/L
1 - 1.9 mg/L
2- 3.9 mg/L
> 4 mg/L
Gila River
Roads
0 1.75 3.5 7 10.5 14
Miles
N

Figure 11 – Perennial flow in the Gila River passes the remnants of Gillespie Dam and is impounded by a diversion dike. The water is subsequently pumped into the Enterprise and Gila Bend canals for irrigation use. Major flooding on the Gila River impacts the basin's groundwater quality by providing a major source of low-salinity recharge. Increased upstream water use and storage facilities may lessen the impact of this important recharge source.

The basin's elevated TDS concentrations will likely increase as a result of saline recharge from excess water applied to crops. This groundwater degradation process is especially pronounced in areas where surface water diverted from the Gila River is used for irrigation. The imported water source maintains relatively shallow groundwater levels, resulting in a short lag time before the saline recharge percolates to the aquifer, impacting groundwater quality. This process explains the significantly higher TDS concentrations found in the Enterprise hydrologic area.

Not all irrigation wells are equally impacted by saline irrigation recharge. Besides variability by hydrologic area, differences in well depth and perforation intervals are major influences on TDS concentrations. TDS increases in the basin have been considerably moderated, however, by fresh recharge from floods on the Gila River. Major flooding occurred 1973, 1978, 1979, 1993, and 2005.

Mean annual flows in the Gila River have declined since 1921 because of increased upstream water use and storage facilities. If this trend continues, fresh recharge from flooding will decrease in quantity and TDS concentrations in groundwater will increase. Future groundwater monitoring should examine whether this trend is occurring and at what rate.

The seven deepest irrigation wells (all greater than 1,390 feet in depth) had low TDS concentrations ranging from 960 – 1,710 mg/L (Figure 5). These wells are likely only perforated at great depth, and do not draw shallow saline groundwater. In contrast, two shallow domestic wells (averaging 400 feet in depth) located in irrigated areas had an average TDS concentration of 6,775 mg/L.

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Appendix A. Data for Sample Sites, Gila Bend Basin, 2012-2015

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Isotope / Hydrologic Area
1st Field Trip, December 20, 2012 – Towne & Boettcher (Equipment Blank – GIL-9)									
GIL-1	C(4-4)04daa turbine	33°06'31.687" 112°40'01.533"	612910	23494	#313	Inorganic, Radon O,H & N Isotopes	650'	214'	Older Cotton Center
GIL-2	C(4-4)09aaa turbine	33°06'05.464" 112°40'01.671"	616740	23499	#308	Inorganic O,H & N Isotopes	-	110'	Older Cotton Center
GIL-3	C(5-5)18ddd turbine	32°59'07.057" 112°48'17.118"	603691	23765	Well #1	Inorganic, Radon O,H & N Isotopes	669'	50'	Younger Painted Rock
GIL-4	C(5-5)22dcc turbine	32°58'15.697" 112°45'40.029"	624273	23775		Inorganic, Radon O,H & N Isotopes	1320'	140'	Younger Painted Rock
GIL-5	C(5-5)24cdd turbine	32°58'15.796" 112°43'34.681"	608563	23780		Inorganic, Radon O,H & N Isotopes	1100'	133'	Older Painted Rock
GIL-6	C(3-4)32daa turbine	33°07'24.519" 112°41'04.002"	624842	23451		Inorganic O,H & N Isotopes	800'	150'	Older Cotton Center
GIL-7	C(3-4)08dcb turbine	33°10'36.738" 112°41'31.164"	622289	23412	PIDD W-8	Inorganic O,H & N Isotopes	745'	-	Older Cotton Center
GIL-8/42	C(3-5)13daa turbine	33°10'00.832" 112°43'11.644"	612576	23462	PN #3	Inorganic, Radon O,H & N Isotopes	-	-	Older Enterprise
2nd Field Trip, February 7-8, 2013 – Towne & Boettcher									
GIL-10	C(6-7)11dcc submersible	32°54'48.74" 112°56'50.10"	622335	23992	PIDD W71-6	Inorganic O,H & N Isotopes	1230'	-	Younger Paloma
GIL-11	C(5-5)18dcb turbine	32°59'19.64" 112°48'47.55"	603693	23758	Well #5	Inorganic, Radiochem O,H & N Isotopes	890'	50'	Younger Painted Rock
GIL-12	C(3-4)09abb turbine	33°11'22.90" 112°40'34.12"	605978	23414		Inorganic, Radiochem O,H & N Isotopes	490'	220'	Older Cotton Center
GIL-13	C(3-4)06caa turbine	33°11'46.70" 112°42'42.61"	622287	23403	PIDD W-5	Inorganic O,H & N Isotopes	815'	159'	Older Cotton Center
3rd Field Trip, March 21, 2013 – Towne & Boettcher									
GIL-14	C(6-6)11dbb turbine	32°54'44.70" 112°50'26.47"	622360	23975	PIDD 76-1	Inorganic, Radiochem Radon, O,H, N isotope	1548'		Older Paloma
GIL-15/16 duplicate	C(6-6)10bcb turbine	32°55'18.53" 112°52'13.49"	085270	48854	PIDD 80-1	Inorganic, Radon O,H & N Isotopes	1394'	263'	Older Paloma
GIL-17	C(6-7)02acc turbine	32°56'01.10" 112°56'52.65"	622337	23986	PIDD 71-8	Inorganic, Radon O,H & N Isotopes	1058'		Younger Paloma
GIL-18	C(5-3)07aba submersible	33°00'46.32" 112°36'16.32"	615044	23690	Windmill Well	Inorganic, Radiochem Radon, O,H, N isotope	500'	358'	Older Gila Bend
GIL-19	C(5-4)31add turbine	32°57'02.76" 112°42'01.56"	622309	01153	PIDD W-28	Inorganic, Radon O,H & N Isotopes	1217'		Older Gila Bend
4th Field Trip, April 2, 2013 – Towne & Boettcher									
GIL-20	C(6-5)05dda turbine	32°55'46.266" 112°47'06.230"	622350	23951	PIDD # 72-5	Inorganic, Radon O,H & N Isotopes	1100'	-	Older Gila Bend
GIL-21	C(6-5)02cdc turbine	32°55'38.490" 112°44'39.098"	622364	23938	PIDD # 77-3	Inorganic, Radiochem Radon, O,H, N isotope	1130'	-	Older Gila Bend
GIL-22	C(6-5)02adb turbine	32°56'10.836" 112°44'09.954"	622311	23936	PIDD # 30	Inorganic, Radon O,H & N Isotopes	1000'	-	Older Gila Bend
GIL-23	C(5-4)9ddd turbine	33°00'00.292" 112°39'57.313"	622323	01145	PIDD # 53	Inorganic, Radon O,H & N Isotopes	1400'	-	Older Gila Bend
GIL-24/25 duplicate	C(5-4)09caa turbine	33°00'21.347" 112°40'35.693"	622359	01146	PIDD # 74-6	Inorganic, Radon O,H & N Isotopes	800'	-	Older Gila Bend
GIL-26	C(4-4)34bac turbine	33°02'24.856" 112°39'39.079"	500153	56795	PIDD # 81-7	Inorganic, Radon O,H & N Isotopes	985'	-	Older Cotton Center
GIL-27	C(4-4)22aaa turbine	33°04'21.002" 112°39'01.572"	622320	01148	PIDD # 43	Inorganic, Radon O,H & N Isotopes	846'	-	Older Cotton Center
GIL-28	C(4-4)10cbc turbine	33°05'31.302" 112°39'55.893"	500154	78381	PIDD #81-12	Inorganic, Radon O,H & N Isotopes	705'	-	Older Cotton Center

Appendix A. Data for Sample Sites, Gila Bend Basin, 2012 -2015----Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Isotope / Hydrologic Area
4th Field Trip, April 2, 2013 – Towne & Boettcher									
GIL-29	C(2-5)26cdd turbine	33°13'09.250" 112°44'21.277"	622283	23353	PIDD #1	Inorganic, Radon O,H & N Isotopes	840’	663’	Older Cotton Center
5th Field Trip, May 21 & 22, 2013 – Towne, Dickens & Boettcher (Equipment Blank – GIL-44)									
GIL-30	C(3-4)33bab turbine	33°07'47.309" 112°40'41.575"	622389	23456	PIDD #81-13	Inorganic, Radon O,H & N Isotopes	755’	-	Older Cotton Center
GIL-31	C(3-4)33adc turbine	33°07'26.237" 112°40'11.963"	622300	23454	PIDD #19	Inorganic, Radon O,H & N Isotopes	800’	-	Older Cotton Center
GIL-32	C(4-4)15acc turbine	33°04'48.311" 112°39'23.453"	622328	23506	PIDD #59	Inorganic, Radon O,H & N Isotopes	977’	-	Older Cotton Center
GIL-33	C(4-4)22ddc turbine	33°03'30.433" 112°39'06.134"	622318	23516	PIDD #41	Inorganic, Radon O,H & N Isotopes	963’	-	Older Cotton Center
GIL-34/35 duplicate	C(5-7)34dcc submersible	32°56'28.737" 112°58'05.815"	597446	78423	D-R Farm Well	Inorganic, Radiochem Radon, O,H, N isotope	378’	165’	Younger Paloma
GIL-36	C(5-5)12daa turbine	33°00'24.900" 112°49'20.076"	-	23796	Rovey #8	Inorganic, Radon O,H & N Isotopes	500’	30’	Older Painted Rock
GIL-37	C(5-4)19ddd turbine	32°58'06.190" 112°42'01.910"	608565	23716	-	Inorganic, Radon O,H & N Isotopes	1000’	130’	Older Painted Rock
GIL-38	C(3-5)02bdb turbine	33°12'02.552" 112°44'56.456"	622201	23460	Hughes #2 Well	Inorganic, Radiochem Radon, O,H, N isotope	979’	23’	Younger Enterprise
GIL-39	C(3-5)02cbb turbine	33°11'47.218" 112°45'11.295"	612574	23461	PN #5	Inorganic, Radon O,H & N Isotopes	320’	12’	Younger Enterprise
GIL-40	C(3-5)13bac turbine	33°10'14.160" 112°43'53.913"	612575	23463	PN #4	Inorganic, Radiochem Radon, O,H, N isotope	1007’	66’	Older Enterprise
GIL-41	C(3-4)19ccd turbine	33°08'43.260" 112°43'00.724"	612571	23432	PS #1	Inorganic, Radon O,H & N Isotopes	1107’	44’	Younger Enterprise
GIL-8/42	C(3-5)13daa turbine	33°10'00.932" 112°43'11.639"	612576	23462	PN #3	Inorganic, Radon O,H & N Isotopes	-	-	Younger Enterprise
GIL-43	C(5-4)21cdd turbine	32°58'18.137" 112°40'31.325"	622382	78441	PIDD #81-6	Inorganic, Radon O,H & N Isotopes	960’	-	Older Gila Bend
GIL-45	C(4-4)09baa2 turbine	33°06'03.717" 112°40'31.611"	612909	23501	#319	Inorganic, Radon O,H & N Isotopes	450’	172’	Older Cotton Center
6th Field Trip, June 13, 2013 – Towne & Boettcher									
GIL-46	C(4-4)08cca turbine	33°05'22.208" 112°41'55.301"	626847	23498	Well #2	Inorganic, Radon O,H & N Isotopes	700’	85’	Older Cotton Center
GIL-47	C(4-4)18dab submersible	33°04'42.261" 112°42'15.998"	626849	23512	South Dm Well	Inorganic, Radiochem Radon, O,H, N isotope	200’		Older Cotton Center
GIL-48	C(4-4)18aab turbine	33°05'12.281" 112°42'18.553"	626848	23511	Well #1	Inorganic, Radon O,H & N Isotopes	600’	87’	Older Cotton Center
GIL-49	C(4-4)31aab turbine	33°02'30.111" 112°41'13.401"	625899	23523	Well #2W	Inorganic, Radiochem Radon, O,H, N isotope	506’		Older Cotton Center
GIL-50	C(4-4)32bcd turbine	33°02'10.918" 112°41'47.984"	625897	23526	Well #3E	Inorganic, Radon O,H & N Isotopes	824’		Older Cotton Center
GIL-51	C(4-4)32cdc turbine	33°01'44.910" 112°41'45.640"	086692	23699	Well #6E	Inorganic, Radon O,H & N Isotopes	715’	-	Older Cotton Center
GIL-52	C(4-4)29dbc turbine	33°02'50.547" 112°41'23.128"	625901	23522	River Well	Inorganic, Radon O,H & N Isotopes	506’		Older Cotton Center
GIL-53/54 duplicate	C(4-4)28baa turbine	33°03'28.479" 112°40'30.730"	625902	23520	Well #1E	Inorganic, Radon O,H & N Isotopes	557’		Older Cotton Center
7th Field Trip, July 1, 2013 – Towne & USGS (Beisner & Sanger)									
GIL-55/56 split/duplicate	C(6-4)20abb submersible	32°53'27.999" 112°40'53.720"	504088	48853	Gila Bend Well #6	Inorganic, Radiochem Radon, O,H, N isotope	618’	324’	Older Gila Bend

Appendix A. Data for Sample Sites, Gila Bend Basin, 2012 -2015----Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Isotope / Hydrologic Area
8th Field Trip, October 17, 2013 – Towne & Boettcher									
GIL-57	C(3-4)11ccc submersible	33°10'30.808" 112°38'55.971"	624967	23421	Bollinger Well	Inorganic, Radiochem Radon, O,H, N isotope	620'	370'	Older Cotton Center
GIL-58	C(3-4)22ddc submersible	33°08'44.468" 112°39'10.709"	803535	23442	Shelton Farms Dm	Inorganic, Radon O,H & N Isotopes			Older Cotton Center
GIL-59	C(6-5)11acb submersible	32°55'22.916" 112°44'25.656"	908865	23956	Hacker Well	Inorganic, Radon O,H & N Isotopes	402'	240'	Older Gila Bend
9th Field Trip, January 21 & 22, 2015 – Towne & Millar									
GIL-60	C(6-5)24cdb submersible	32.88585 -112.72817	609893	59058	USAF GB Well #4	Inorganic, Radiochem Radon, O,H, N isotope	601'	297'	Older Gila Bend
GIL-61	C(6-5)25bba submersible	32.88197 -112.73067	609892	59057	USAF GB Well #3	Inorganic, Radon O,H & N Isotopes	613'	335'	Older Gila Bend
GIL-62	C(6-7)11acb turbine	32.92326 -112.94735	622349	23989	PIDD #72-4	Inorganic, Radiochem O,H & N Isotopes	1230'		Younger Paloma
GIL-63	C(5-4)31bbd turbine	32.95362 -112.71488	618959	23732	Gila Bend #4	Inorganic, Radiochem Radon, O,H N Isotope	1710'		Older Gila Bend
GIL-64	C(5-5)23cdd submersible	32.97155 -112.74406	612837	79762	Gila Bend WW Well	Inorganic, Radiochem O,H, N isotope	419'	170'	Younger Painted Rock
GIL-65	C(6-4)20aad submersible	32.89642 -112.68193	573124	60283	Gila Bend #7	Inorganic O,H & N Isotopes	770'		Older Gila Bend
GIL-66	C(5-4)28cac submersible	32.96135 -112.67782	806739	23724	Gila Bend Airport	Inorganic, Radon O,H & N Isotopes			Older Gila Bend
GIL-67/68 duplicate	C(6-4)06daa submersible	32.93383 -112.69900	-	79763	Sizemore Well	Inorganic O,H & N Isotopes	300'	218'	Older Gila Bend
GIL-69	C(3-4)31cbd turbine	33.11990 -112.71623	612579	79761	4S Well	Inorganic O,H & N Isotopes	860'	91'	Older Enterprise
10th Field Trip, February 25 & 26, 2015 – Towne & Spindler / Boettcher									
GIL-70/71 split	C(4-4)07dbc submersible	33.091283 -112.708900	915801	79821	Nigro Well	Inorganic, Radiochem Radon, O,H N Isotope	360'	220'	Older Cotton Center
GIL-72	C(5-5)21ccc turbine	32.97135 -112.787133	913500	79822	Feedlot Well	Inorganic O,H & N Isotopes	1503'	110'	Older Painted Rock
GIL-73	C(5-5)20dca turbine	32.973366 -112.792816	622372	23768	PIDD 81-7 Well	Inorganic O,H & N Isotopes	1811'	120'	Older Painted Rock
GIL-74	C(5-5)20cbb turbine	32.976916 -112.8044	622334	23767	Citrus Vly Well	Inorganic O,H & N Isotopes	920'	180'	Older Painted Rock
GIL-75	C(5-5)23cdd turbine	32.971183 -112.744033	612836	79841	O & E Well #1	Inorganic O,H & N Isotopes	1300'	90'	Older Painted Rock
GIL-76	C(5-5)24cdd turbine	32.971183 -112.726283	608563	23780	O & E Well #2	Inorganic O,H & N Isotopes	1100'	133'	Older Painted Rock
GIL-77	C(5-6)01cdd turbine	33.014616 -112.830983	627765	23785	Sunset Farms #1	Inorganic O,H & N Isotopes	900'	-	Older Painted Rock
GIL-78	C(5-6)31cbb turbine	32.947833 -112.924816	622330	23805	PIDD W-12 Well	Inorganic, Radiochem Radon, O,H N Isotope	1785'	-	Younger Paloma
GIL-79	C(2-4)33cbc turbine	33.20695 -112.6847	605987	23333	Bioflora Well #12	Inorganic, Radon O,H & N Isotopes	639'	237'	Older Cotton Center
GIL-80/81 duplicate	C(2-4)32dcd turbine	33.204916 -112.689383	605983	23326	Bioflora Well #8	Inorganic, Radiochem O,H, N isotope	500'	232'	Older Cotton Center
GIL-82	C(3-4)07dda turbine	33.17765 -112.70265	-	79842	PIDD 80-3 Well	Inorganic O,H & N Isotopes	-	-	Older Cotton Center
GIL-83	C(5-5)24ddc turbine	32.9712 -112.721966	608564	23781	O & E Well #3	Inorganic O,H & N Isotopes	1100'	130'	Older Painted Rock
GIL-84	C(5-6)02bbc turbine	33.025916 -112.857	627763	23788	Sunset Farms #2	Inorganic O,H & N Isotopes	600'		Older Painted Rock
GIL-85	C(5-7)36cbb turbine	32.947833 -112.942166	622354	23816	PIDD 72-13 Well	Inorganic O,H & N Isotopes	1300'	-	Younger Paloma

Appendix A. Data for Sample Sites, Gila Bend Basin, 2012 -2015----Continued

Site #	Cadastral / Pump Type	Latitude - Longitude	ADWR #	ADEQ #	Site Name	Samples Collected	Well Depth	Water Depth	Isotope / Hydrologic Area
			11th Field Trip, March 12, 2015 – Towne (Equipment Blank – GIL-87)						
GIL-86	C(2-5)35ddd turbine	33.20428 -112.72903	085350	79843	PIDD 81-1 Well	Inorganic O,H & N Isotopes	651'	180'	Older Cotton Center
GIL-88	C(5-5)16cdd turbine	32.98537 -112.77868	609772	23753	River Well	Inorganic O,H & N Isotopes	616'	253'	Younger Painted Rock
GIL-89	C(6-4)06ada submersible	32.93760 -112.69907	649706	79844	King Well	Inorganic O,H & N Isotopes	320'	180'	Older Gila Bend

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015

Site #	MCL Exceedances	Temp (°C)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Strontium (mg/L)	Turb (ntu)
GIL-1	TDS, Cl, SO_4,	23.9	7.24	*7.43*	2987	3000	**1800**	640	2.5	*ND*
GIL-2	TDS, Cl, SO_4,	24.1	7.20	7.35	2931	2900	**1800**	580	2.5	ND
GIL-3	TDS, Cl, SO_4, NO_3, F	24.8	7.02	*7.21*	7880	7900	**5200**	1300	5.0	0.73
GIL-4	TDS, Cl, SO_4, NO_3, F	25.4	7.29	*7.44*	7202	7000	**4500**	960	2.5	ND
GIL-5	TDS, Cl, SO_4, NO_3, F	27.1	7.59	*7.75*	3663	3500	**2200**	540	3.7	ND
GIL-6	TDS, Cl,	22.2	7.23	*7.41*	2314	2300	**1400**	590	1.4	ND
GIL-7	TDS, Cl, SO_4, NO_3,	23.1	7.16	*7.37*	4147	4200	**2700**	930	2.3	ND
GIL-8	TDS, Cl, SO_4,	21.2	6.96	*7.18*	4633	4600	**3100**	1100	2.7	ND
GIL-10	TDS, Cl, SO_4, NO_3, F, As	32.2	8.61	*8.75*	3869	3900	**2300**	480	0.54	ND
GIL-11	TDS, Cl, SO_4, NO_3	25.6	6.93	*7.27*	10,943	11,000	**7700**	2200	9.0	ND
GIL-12	TDS, Cl, SO_4, NO_3, F	30.4	7.39	*7.67*	4763	4700	**2900**	770	4.8	0.20
GIL-13	TDS, Cl, SO_4	25.6	8.14	*7.34*	3659	3700	**2400**	850	2.4	ND
GIL-14	TDS, Cl, **F**, As	31.8	8.30	*8.39*	1869	2000	**1600**	120	0.57	ND
GIL-15/16	TDS, Cl, As, **F**	30.8	8.42	*8.48*	1746	1900	**1000**	91	0.425	0.86
GIL-17	TDS, Cl, SO_4, NO_3, F	31.0	7.56	*7.68*	6604	7000	**4600**	1300	4.1	ND
GIL-18	TDS, Cl, **F**	35.3	7.88	*8.00*	1933	2100	**1100**	100	0.87	6.4
GIL-19	TDS, Cl, **F**	29.6	7.93	*8.00*	2394	2600	**1400**	180	1.4	ND
GIL-20	TDS, Cl, As, **F**	32.0	8.14	8.27	1983	2000	**1200**	120	0.72	ND
GIL-21	TDS, Cl, As, **F**	35.9	8.25	*8.31*	1937	2000	**1100**	85	0.69	ND
GIL-22	TDS, Cl, As, **F**	36.1	8.06	*8.13*	2403	2400	**1400**	180	1.3	ND
GIL-23	TDS, Cl, **F**	29.2	7.75	7.83	2420	2500	**1400**	190	1.5	ND
GIL-24/25	TDS, Cl, F	28.0	7.70	*7.77*	2427	2500	**1400**	230	1.85	ND
GIL-26	TDS, Cl, SO_4, NO_3, F	30.1	7.19	*7.33*	4498	4600	**3000**	820	5.3	ND
GIL-27	TDS, Cl, F	30.9	7.66	*7.76*	2336	2400	**1400**	260	1.7	ND
GIL-28	TDS, Cl	26.1	7.21	*7.33*	2633	2800	**1800**	610	2.6	ND
GIL-29	TDS, Cl, SO_4	24.6	7.34	*7.51*	3633	3900	**2400**	820	3.1	ND
GIL-30	TDS, Cl, SO_4	22.4	7.06	*7.31*	3258	3600	**2100**	750	1.7	ND
GIL-31	TDS, Cl, SO_4	26.4	7.20	*7.35*	3322	3700	**2300**	700	2.4	ND

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	MCL Exceedances	Temp (°C)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Strontium (mg/L)	Turb (ntu)
GIL-32	TDS, Cl, F	33.0	7.39	*7.62*	2036	2300	**1300**	300	1.8	*ND*
GIL-33	TDS, Cl, F	31.0	7.30	7.53	2625	2800	**1600**	410	2.4	ND
GIL-34/35	TDS, Cl, SO_4, NO_3, U	30.8	7.17	*7.47*	9230	10000	**7550**	2700	15	1.05
GIL-36	TDS, Cl, SO_4	28.5	7.59	*7.53*	3994	3900	**2700**	980	4.9	ND
GIL-37	TDS, Cl, F	29.3	7.90	*7.74*	2952	3200	**1800**	350	2.2	ND
GIL-38	TDS, Cl, SO_4	21.3	7.91	*7.23*	3522	3900	**2400**	780	1.9	ND
GIL-39	TDS, Cl, SO_4	23.4	7.62	*7.06*	5262	5800	**3800**	1400	3.6	ND
GIL-40	TDS, Cl, SO_4	24.5	7.67	*7.69*	4100	4500	**3300**	1300	3.2	ND
GIL-41	TDS, Cl, SO_4, NO_3	25.0	7.35	*7.03*	6926	6400	**7700**	2800	9.2	ND
GIL-42	TDS, Cl, SO_4	23.1	7.70	*7.20*	4363	4800	**3300**	1300	3.1	ND
GIL-43	TDS, Cl, F	28.1	7.91	*7.81*	2388	2600	**1400**	200	1.6	ND
GIL-45	TDS, Cl	25.1	7.79	*7.46*	2123	2300	**1600**	580	1.9	ND
GIL-46	TDS, Cl, SO_4	26.0	7.15	*7.40*	2743	2800	**1700**	510	1.6	ND
GIL-47	TDS, Cl, SO_4	29.4	7.09	*7.37*	3310	3400	**2400**	820	2.7	1.6
GIL-48	TDS, Cl, SO_4	26.8	7.06	*7.35*	3283	3300	**2000**	620	1.9	ND
GIL-49	TDS, Cl, F	30.3	7.21	*7.60*	2471	2500	**1700**	510	1.8	ND
GIL-50	TDS, Cl, SO_4 F	30.4	6.90	*7.30*	3382	3500	**2400**	770	2.6	ND
GIL-51	TDS, Cl, SO_4, NO_3,	25.5	6.43	7.00	7278	7600	**5600**	2000	7.0	0.21
GIL-52	TDS, Cl, F	29.1	7.35	*7.66*	2199	2300	**1300**	360	1.5	ND
GIL-53/54	TDS, Cl	31.4	7.12	*7.57*	2244	2200	**1450**	410	1.9	ND
GIL-55/56	TDS, Cl, **F**	32.0	8.47	8.18	1607	1600	**985**	130	0.675	ND
GIL-57	TDS, Cl, **F**	28.1	7.96	*7.79*	2014	2100	**1200**	160	1.3	ND
GIL-58	TDS, Cl, SO_4, NO_3, F	28.3	7.67	*7.57*	4955	5400	**3400**	760	6.0	ND
GIL-59	TDS, Cl, **F**	26.1	8.32	*8.21*	1972	2100	**1200**	130	0.64	0.24
GIL-60	TDS, Cl, As, **F**	31.3	8.22	*8.15*	1915	1710	**1050**	111	0.646	1.7
GIL-61	TDS, Cl, As, **F**	34.0	8.05	*8.23*	2114	1820	**1100**	142	0.852	ND
GIL-62	TDS, Cl, SO_4, NO_3,As	30.9	8.05	*8.26*	5132	4460	**2980**	607	1.25	ND
GIL-63	TDS, pH, Cl, As, **F**	39.8	**8.54**	*8.34*	2458	2190	**1290**	91	0.423	0.57

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	MCL Exceedances	Temp (°C)	pH-field (su)	pH-lab (su)	SC-field (µS/cm)	SC-lab (µS/cm)	TDS (mg/L)	Hard (mg/L)	Strontium (mg/L)	Turb (ntu)
GIL-64	TDS, Cl, SO_4, NO_3, U	22.1	7.20	*7.68*	8660	9040	**6000**	1430	8.68	*1.1*
GIL-65	TDS, Cl, As, **F**	28.1	8.09	8.06	1966	1780	**1030**	112	0.509	ND
GIL-66	TDS, Cl, F	27.3	7.69	*7.98*	2420	2150	**1330**	168	1.34	38.9
GIL-67/68	TDS, Cl, As, **F**	25.9	7.84	*7.95*	2263	2040	**1220**	148.5	1.32	ND
GIL-69	TDS, Cl, SO_4,	22.4	6.92	*7.54*	4953	4450	**3170**	990	2.97	ND
GIL-70/71	TDS, Cl,	26.1	7.43	*7.51*	1902	1985	**1150**	323.5	1.02	ND
GIL-72	TDS, Cl, F	29.4	7.81	*7.94*	2780	2860	**1710**	275	1.84	ND
GIL-73	TDS, Cl, As, F	30.3	7.97	*8.07*	2142	2130	**1340**	158	1.04	ND
GIL-74	TDS, Cl, As, F	29.3	7.97	*8.08*	2295	2380	**1470**	214	1.23	ND
GIL-75	TDS, Cl, SO_4, NO_3, F	28.6	7.28	*7.17*	4212	4780	**3230**	766	5.02	ND
GIL-76	TDS, Cl, SO_4, NO_3, F	27.9	7.37	*7.43*	3291	3580	**2240**	654	4.56	ND
GIL-77	TDS, Cl, SO_4,	26.0	7.08	*7.21*	4153	4700	**3260**	1340	6.05	ND
GIL-78	TDS, pH, Cl, As. **F**	32.2	**8.54**	***8.70***	1432	1540	**960**	72.1	0.231	ND
GIL-79	TDS, Cl, SO_4, NO_3, F	30.2	7.51	*7.78*	3626	3940	**2640**	611	4.40	ND
GIL-80/81	TDS, Cl, SO_4, NO_3,U	27.3	7.09	*6.90*	4897	5720	**4175**	1305	6.095	ND
GIL-82	TDS, Cl, SO_4, Al	21.4	7.34	*7.27*	2378	2460	**1760**	625	1.50	ND
GIL-83	TDS, Cl, As, F, Al	29.1	7.87	*7.78*	2112	2160	**1580**	177	1.05	ND
GIL-84	TDS, Cl	25.7	7.08	7.11	4444	5070	**3770**	1350	6.83	ND
GIL-85	TDS, Cl, SO_4, NO_3, As, F	34.0	7.97	*8.10*	4109	4570	**3160**	685	2.97	ND
GIL-86	TDS, Cl, SO_4	23.7	7.97	*7.41*	3419	3380	**2220**	885	2.61	ND
GIL-88	TDS, Cl, SO_4 NO_3	26.4	7.33	7.24	5962	6540	**3870**	1020	5.46	ND
GIL-89	TDS, Cl, As, F	27.3	8.01	*7.86*	2170	2110	**1270**	163	1.37	ND

italics = constituent exceeded holding time

bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
GIL-1	210	32	410	9.9	160	195	ND	**790**	**270**
GIL-2	180	31	410	9.1	180	220	ND	**770**	**260**
GIL-3	340	100	130*	14	220	268	ND	**2000**	**1200**
GIL-4	960	59	130*	14	140	171	ND	**1900**	**1100**
GIL-5	200	11	550	12	87	106	ND	**1000**	**270**
GIL-6	160	47	240	6.4	150	183	ND	**590**	210
GIL-7	240	80	540	7.8	170	207	ND	**1100**	**550**
GIL-8	310	81	460	7.0	190	232	ND	**1200**	**680**
GIL-10	190	ND	650	2.6	14	17	ND	**1100**	**490**
GIL-11	570	190	1900	18	220	268	ND	**3000**	**1900**
GIL-12	260	28	730	13	88	107	ND	**1300**	**700**
GIL-13	230	67	460	8.0	140	171	ND	**990**	**470**
GIL-14	44	2.7	350	4.2	41	50	ND	**460**	170
GIL-15/16	34.5	2	325	3.7	39	48	ND	**430**	150
GIL-17	460	23	1100	10	41	50	ND	**1600**	**1300**
GIL-18	41	ND	360	6.9	60	73	ND	**500**	140
GIL-19	68	2.8	420	8.4	65	79	ND	**660**	160
GIL-20	43	3.1	350	5.4	43	53	ND	**520**	160
GIL-21	34	ND	350	5.3	50	61	ND	**490**	160
GIL-22	64	4.0	440	7.9	46	56	ND	**680**	160
GIL-23	70	4.1	460	10	110	134	ND	**670**	160
GIL-24/25	84	4.85	430	10	98	120	ND	**625**	210
GIL-26	280	30	720	14	130	159	ND	**1200**	**610**
GIL-27	90	8.4	400	9.5	100	122	ND	**650**	170
GIL-28	180	39	310	8.4	150	183	ND	**740**	220
GIL-29	220	68	490	9.5	120	146	ND	**1000**	**430**
GIL-30	220	49	490	5.7	200	244	ND	**890**	**360**
GIL-31	210	42	480	7.1	170	207	ND	**940**	**320**

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level
* sodium concentrations were likely unreported in these samples

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
GIL-32	100	13	340	8.5	120	146	ND	**540**	150
GIL-33	140	14	440	11	120	146	ND	**720**	220
GIL-34/35	900	99	1450	18	110	134	ND	**2500**	**2350**
GIL-36	300	55	430	13	160	195	ND	**1100**	**310**
GIL-37	130	7.0	540	12	83	101	ND	**860**	210
GIL-38	190	74	520	7.9	160	195	ND	**1000**	**510**
GIL-39	360	120	810	11	310	378	ND	**1400**	**800**
GIL-40	360	97	460	9.2	180	220	ND	**1200**	**550**
GIL-41	740	230	620	15	170	207	ND	**2300**	**980**
GIL-42	370	95	530	8.4	190	232	ND	**1300**	**740**
GIL-43	76	3.0	440	9.6	96	117	ND	**760**	180
GIL-45	160	44	230	7.0	130	159	ND	**600**	150
GIL-46	140	38	390	6.4	190	232	ND	**670**	**300**
GIL-47	210	73	350	8.6	180	220	ND	**910**	**320**
GIL-48	160	54	450	7.4	170	207	ND	**880**	**320**
GIL-49	140	39	290	7.6	140	171	ND	**670**	170
GIL-50	210	60	370	8.1	140	171	ND	**960**	**260**
GIL-51	530	160	860	15	230	281	ND	**2300**	**710**
GIL-52	100	27	310	6.7	140	171	ND	**540**	210
GIL-53/54	120	26.5	265	8.15	98.5	120.5	ND	**565**	205
GIL-55/56	35	11	290	2.3	64.5	79.5	ND	**450**	110
GIL-57	61	2.9	380	8.6	99	121	ND	**530**	160
GIL-58	280	15	840	18	100	122	ND	**1300**	**790**
GIL-59	44	4.6	360	7.3	64	78	ND	**560**	130
GIL-60	39.5	ND	302	3.84	46.5	56.7	ND	**411**	136
GIL-61	50.5	ND	333	4.42	49.5	60.4	ND	**480**	151
GIL-62	238	ND	661	4.34	19.1	23.3	ND	**1310**	**587**
GIL-63	36	ND	396	2.40	24.8	30.3	ND	**626**	171

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Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012 ----Continued

Site #	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T. Alk (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
GIL-64	449	74.1	965	15.25	131	159.8	ND	**2170**	**1090**
GIL-65	35.2	5.89	306	3.61	49.6	60.5	ND	**464**	111
GIL-66	63.4	ND	365	8.15	94.9	115.8	ND	**593**	148
GIL-67/68	55.25	ND	355.5	6.75	58.7	71.7	ND	**560.5**	129
GIL-69	262	81.6	585	9.34	265	323.3	ND	**1070**	**538**
GIL-70/71	85.7	26.95	296	6.79	140	171	ND	**477.5**	146
GIL-72	101	5.52	583	10.2	-	-	-	**840**	220
GIL-73	57.7	ND	455	7.57	-	-	-	**546**	157
GIL-74	76.8	5.34	507	8.92	-	-	-	**634**	187
GIL-75	269	23.0	875	13.6	-	-	-	**1320**	**507**
GIL-76	237	15.2	585	16.7	-	-	-	**1060**	**283**
GIL-77	378	96.1	608	15.9	-	-	-	**1460**	**505**
GIL-78	27.6	ND	342	3.37	-	-	-	**386**	166
GIL-79	215	18.1	783	14.3	-	-	-	**1030**	**508**
GIL-80/81	397	76.6	836	15.35	111	135	ND	**1445**	**892**
GIL-82	166	51.1	371	7.32	172	210	ND	**581**	**322**
GIL-83	66.1	ND	468	9.05	80.8	98.5	ND	**565**	173
GIL-84	410	78.3	619	18.1	99.0	121	ND	**1560**	207
GIL-85	260	8.59	838	8.61	24.2	29.5	ND	**1380**	**359**
GIL-86	219	82.1	443	7.52	152	185	ND	**899**	**454**
GIL-88	297	68.5	1100	11.9	165	201	ND	**1750**	**755**
GIL-89	60.9	ND	399	33.2	67.6	82.5	ND	**595**	147

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Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015

Site #	Nitrate-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	T. Phos. (mg/L)	SAR (value)	Irrigation Quality	Alum (mg/L)
GIL-1	7.1	11.8	ND	ND	ND	ND	7.0	C4-S2	ND
GIL-2	6.9	12.4	ND	ND	ND	ND	7.4	C4-S2	ND
GIL-3	**19**	11.9	ND	0.29	ND	ND	1.6	C4-S1	ND
GIL-4	**30**	8.3	ND	ND	ND	0.12	1.8	C4-S1	ND
GIL-5	**15**	9.8	ND	ND	ND	ND	10.3	C4-S3	ND
GIL-6	5.1	12.4	ND	0.24	0.055	ND	4.3	C4-S2	ND
GIL-7	**13**	6.5	ND	ND	ND	ND	7.7	C4-S3	ND
GIL-8	9.9	10.9	ND	ND	ND	ND	6.0	C4-S2	ND
GIL-10	**11**	7.5	ND	ND	ND	ND	12.9	C4-S3	ND
GIL-11	**16**	12.9	ND	ND	ND	ND	17.6	C4-S4	ND
GIL-12	**11**	8.4	ND	ND	ND	ND	11.5	C4-S3	ND
GIL-13	8.9	15.5	ND	ND	ND	ND	6.9	C4-S3	ND
GIL-14	3.0	9.2	ND	ND	ND	ND	13.8	C3-S3	ND
GIL-15/16	2.8	8.55	ND	ND	ND	ND	5.7	C3-S2	ND
GIL-17	**16**	6.8	ND	ND	ND	ND	13.6	C4-S4	ND
GIL-18	ND	ND	ND	ND	0.10	ND	15.2	C3-S4	ND
GIL-19	3.3	10.5	ND	ND	ND	ND	13.6	C4-S3	ND
GIL-20	2.9	8.9	ND	ND	ND	ND	8.6	C3-S2	ND
GIL-21	2.6	8.6	ND	ND	ND	ND	16.1	C4-S4	ND
GIL-22	3.1	10.3	ND	ND	ND	ND	6.9	C4-S4	ND
GIL-23	1.8	10.4	ND	ND	ND	ND	14.5	C4-S4	ND
GIL-24/25	6.8	12.9	ND	ND	ND	ND	11.9	C4-S3	ND
GIL-26	**15**	11.1	ND	ND	ND	ND	10.9	C4-S3	ND
GIL-27	1.5	12.0	ND	ND	ND	ND	10.8	C4-S3	ND
GIL-28	4.8	17.4	ND	ND	ND	ND	5.5	C4-S2	ND
GIL-29	4.2	18.4	ND	ND	ND	ND	7.4	C4-S2	ND
GIL-30	6.2	12.2	ND	ND	0.019	0.052	7.8	C4-S2	ND
GIL-31	8.1	13.5	ND	ND	ND	0.063	7.9	C4-S2	ND

italics = constituent exceeded holding time
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Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Nitrate-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	T. Phos. (mg/L)	SAR (value)	Irrigation Quality	Alum (mg/L)
GIL-32	1.5	17.8	ND	ND	ND	0.086	8.5	C4-S2	ND
GIL-33	2.8	13.9	ND	ND	ND	0.078	9.5	C4-S3	ND
GIL-34/35	**18**	12.1	ND	1.7	0.0195	0.0305	12.9	C4-S4	ND
GIL-36	4.9	19.9	ND	0.25	0.030	0.064	6.0	C4-S2	ND
GIL-37	9.7	10.7	ND	ND	ND	0.017	12.5	C4-S3	ND
GIL-38	5.9	23.3	ND	0.88	0.037	0.059	8.1	C4-S2	ND
GIL-39	7.7	18.6	ND	ND	ND	0.041	9.4	C4-S3	ND
GIL-40	8.0	19.0	ND	0.54	0.045	0.029	5.6	C4-S2	ND
GIL-41	**15**	16.0	ND	ND	ND	0.038	5.1	C4-S2	ND
GIL-42	9.1	13.3	ND	ND	0.024	0.028	6.4	C4-S2	ND
GIL-43	2.0	11.5	ND	ND	ND	0.067	13.5	C4-S4	ND
GIL-45	4.3	20.8	ND	ND	ND	0.061	4.2	C4-S2	ND
GIL-46	7.6	15.0	ND	6.1	0.076	ND	7.5	C4-S2	ND
GIL-47	2.6	9.4	ND	ND	0.026	ND	5.3	C4-S2	ND
GIL-48	5.2	18.3	ND	ND	0.081	ND	7.9	C4-S2	ND
GIL-49	2.4	19.2	ND	ND	0.037	ND	5.6	C4-S2	ND
GIL-50	6.7	12.0	ND	0.21	0.039	ND	5.8	C4-S2	-
GIL-51	**16**	12.1	ND	ND	0.0076	ND	8.4	C4-S3	ND
GIL-52	3.3	21.4	ND	ND	0.0061	ND	7.1	C4-S2	ND
GIL-53/54	5.85	15.5	ND	ND	0.0455	ND	5.6	C4-S2	ND
GIL-55/56	4.8	9.55	ND	ND	0.0385	ND	11.0	C4-S3	ND
GIL-57	5.0	11.3	ND	ND	0.072	ND	12.9	C3-S3	ND
GIL-58	**22**	9.4	ND	ND	0.079	ND	13.2	C4-S4	ND
GIL-59	1.5	10.1	ND	0.41	0.046	ND	13.8	C3-S3	ND
GIL-60	2.9	9.9	ND	ND	ND	0.038	12.6	C3-S3	ND
GIL-61	4.2	8.5	ND	ND	ND	ND	12.4	C3-S3	ND
GIL-62	**12.9**	6.3	ND	ND	ND	ND	11.7	C4-S3	ND
GIL-63	1.8	8.5	ND	ND	ND	0.056	17.2	C3-S4	ND

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Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Nitrate-N (mg/L)	$\delta^{15}N$ ($^0/_{00}$)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	T. Phos. (mg/L)	SAR (value)	Irrigation Quality	Alum (mg/L)
GIL-64	**41.2**	8.4	ND	ND	ND	ND	11.1	C4-S3	ND
GIL-65	3.1	9.2	0.13	ND	ND	ND	12.6	C3-S3	ND
GIL-66	1.0	9.5	ND	ND	ND	0.061	12.2	C3-S3	ND
GIL-67/68	1.5	9.8	ND	ND	ND	ND	12.8	C3-S3	ND
GIL-69	7.2	14.4	0.10	ND	ND	0.036	12.6	C4-S3	ND
GIL-70/71	0.42	8.9	ND	ND	ND	ND	7.7	C3-S2	ND
GIL-72	5.3	12.2	ND	ND	ND	ND	15.3	C4-S3	ND
GIL-73	2.5	11.4	ND	ND	ND	ND	15.9	C4-S3	ND
GIL-74	2.0	9.8	ND	ND	ND	ND	15.1	C4-S3	ND
GIL-75	**13.7**	10.2	ND	ND	ND	ND	13.7	C4-S3	ND
GIL-76	**16.8**	11.3	ND	ND	ND	ND	9.9	C4-S3	ND
GIL-77	4.9	12.2	ND	ND	ND	ND	7.2	C4-S2	ND
GIL-78	2.8	8.9	ND	ND	ND	ND	16.7	C3-S4	ND
GIL-79	**10**	11.2	ND	ND	ND	ND	13.8	C4-S3	ND
GIL-80/81	**16.95**	9.6	ND	ND	ND	ND	9.9	C4-S3	ND
GIL-82	6.1	12.7	ND	ND	ND	ND	6.5	C4-S2	**0.288**
GIL-83	4.5	11.4	ND	ND	ND	ND	15.4	C4-S3	**0.369**
GIL-84	1.1	10.9	ND	ND	ND	ND	7.3	C4-S2	ND
GIL-85	**11.9**	8.1	ND	ND	ND	ND	13.9	C4-S3	ND
GIL-86	6.7	19.4	ND	ND	ND	ND	6.5	C4-S2	ND
GIL-88	**17.2**	9.5	ND	ND	ND	ND	15.0	C4-S4	ND
GIL-89	1.5	10.6	ND	ND	ND	0.32	13.6	C3-S3	ND

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Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
GIL-1	ND	0.0032	0.074	ND	0.46	ND	0.0014	0.0044	1.1
GIL-2	ND	ND	0.044	ND	0.57	ND	ND	0.0043	0.63
GIL-3	ND	0.0038	0.043	ND	4.7	ND	0.0020	0.015	**2.9**
GIL-4	ND	0.0051	0.038	ND	3.1	ND	0.0025	0.016	**3.4**
GIL-5	ND	0.0073	0.095	ND	1.0	ND	0.0021	0.0074	**3.1**
GIL-6	ND	ND	0.069	ND	0.20	ND	ND	ND	ND
GIL-7	ND	ND	0.052	ND	1.1	ND	0.0017	0.0066	0.57
GIL-8	ND	ND	0.063	ND	0.75	ND	ND	0.0067	ND
GIL-10	ND	**0.011**	0.0083	ND	2.9	ND	0.0056	0.0066	**3.1**
GIL-11	ND	0.0052	0.054	ND	5.0	ND	ND	0.015	1.0
GIL-12	ND	0.0034	0.066	ND	1.7	ND	ND	0.0074	**2.8**
GIL-13	ND	0.0036	0.053	ND	0.85	ND	0.0013	0.0038	1.5
GIL-14	ND	**0.020**	0.030	ND	1.5	ND	0.012	0.0046	**5.4**
GIL-15/16	ND	**0.020**	0.0355	ND	1.5	ND	0.013	0.0040	**5.7**
GIL-17	ND	0.0061	0.052	ND	3.8	ND	0.0043	0.011	**2.1**
GIL-18	ND	ND	0.043	ND	0.97	ND	ND	0.0040	**5.6**
GIL-19	ND	0.0086	0.080	ND	1.1	ND	0.0080	0.0044	**4.0**
GIL-20	ND	**0.020**	0.022	ND	1.1	ND	0.0098	ND	**5.8**
GIL-21	ND	**0.021**	0.047	ND	0.94	ND	0.0097	ND	**6.0**
GIL-22	ND	**0.016**	0.058	ND	0.88	ND	0.0087	0.0031	**5.3**
GIL-23	ND	0.0039	0.047	ND	0.99	ND	ND	0.0040	**4.0**
GIL-24/25	ND	0.00785	0.0535	ND	0.58	ND	ND	0.0036	**2.3**
GIL-26	ND	0.0041	0.059	ND	1.4	ND	ND	0.0053	**2.0**
GIL-27	ND	0.0055	0.061	ND	0.77	ND	ND	0.0032	**3.6**
GIL-28	ND	0.0037	0.064	ND	0.37	ND	ND	ND	0.62
GIL-29	ND	0.0059	0.058	ND	0.86	ND	0.0022	0.0035	0.96
GIL-30	ND	ND	0.054	ND	0.65	ND	ND	0.0070	0.32
GIL-31	ND	ND	0.056	ND	0.65	ND	0.0011	0.0078	1.4

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
GIL-32	ND	0.0018	0.079	ND	0.63	ND	ND	0.0052	**3.3**
GIL-33	ND	ND	0.054	ND	0.91	ND	0.0017	0.0075	**2.7**
GIL-34/35	ND	0.00155	0.055	ND	3.2	ND	0.0022	0.0061	0.82
GIL-36	ND	ND	0.068	ND	0.51	ND	0.0012	0.0066	1.3
GIL-37	ND	0.0031	0.054	ND	1.3	ND	0.0031	0.0087	**3.9**
GIL-38	ND	ND	0.031	ND	1.1	ND	0.0015	0.010	0.91
GIL-39	ND	ND	0.054	ND	2.0	ND	0.0012	0.018	0.64
GIL-40	ND	ND	0.059	ND	0.76	ND	ND	0.0079	0.28
GIL-41	ND	0.0018	0.084	ND	0.49	ND	ND	0.0036	0.098
GIL-42	ND	ND	0.056	ND	0.83	ND	0.0010	0.010	0.21
GIL-43	ND	0.0036	0.044	ND	1.0	ND	0.0032	0.0066	**3.7**
GIL-45	ND	ND	0.073	ND	0.18	ND	ND	0.0039	0.33
GIL-46	ND	0.0039	0.052	ND	0.49	ND	ND	ND	0.57
GIL-47	ND	0.0019	0.038	ND	0.39	ND	ND	0.00065	0.41
GIL-48	ND	0.0031	0.051	ND	0.72	ND	ND	ND	0.29
GIL-49	ND	0.0041	0.092	ND	0.33	ND	ND	ND	**2.5**
GIL-50	0.00061	0.0032	0.092	ND	0.47	ND	ND	0.0016	**2.0**
GIL-51	ND	0.0019	0.11	ND	1.0	ND	ND	0.0014	0.72
GIL-52	ND	0.0041	0.089	ND	0.48	ND	ND	ND	**2.9**
GIL-53/54	ND	0.0025	0.0625	ND	0.365	ND	ND	ND	1.5
GIL-55/56	ND	0.00405	0.0225	ND	0.645	ND	0.0125	.000605	**4.35**
GIL-57	ND	ND	0.042	ND	0.93	ND	0.011	ND	**5.6**
GIL-58	ND	ND	0.047	ND	2.3	ND	0.014	ND	**2.7**
GIL-59	ND	0.0095	0.027	ND	0.74	ND	0.012	0.0099	**5.9**
GIL-60	ND	**0.0208**	ND	ND	1.11	ND	ND	ND	**4.6**
GIL-61	ND	**0.0217**	ND	ND	1.17	ND	0.0102	ND	**4.7**
GIL-62	ND	**0.0109**	ND	ND	3.45	ND	ND	ND	1.5
GIL-63	ND	**0.0166**	ND	ND	0.841	ND	0.0125	ND	**4.2**

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Fluoride (mg/L)
GIL-64	ND	ND	ND	ND	2.90	ND	ND	ND	1.4
GIL-65	ND	**0.0129**	ND	ND	0.728	ND	0.0104	ND	**5.0**
GIL-66	ND	ND	ND	ND	0.972	ND	ND	ND	**3.1**
GIL-67/68	ND	**0.01205**	ND	ND	1.095	ND	ND	ND	**4.1**
GIL-69	ND	ND	ND	ND	1.29	ND	ND	ND	0.65
GIL-70/71	ND	0.0044	0.04795	ND	0.516	ND	ND	ND	1.65
GIL-72	ND	0.0073	0.0282	ND	0.898	ND	ND	ND	**2.3**
GIL-73	ND	**0.0115**	0.0123	ND	0.870	ND	ND	ND	**3.2**
GIL-74	ND	**0.0129**	0.0315	ND	0.976	ND	ND	ND	**3.7**
GIL-75	ND	0.0068	0.0427	ND	1.66	ND	ND	ND	**2.2**
GIL-76	ND	0.0069	0.0936	ND	1.02	ND	ND	ND	**2.3**
GIL-77	ND	0.0064	0.0514	ND	0.722	ND	ND	ND	1.2
GIL-78	ND	**0.0298**	0.0147	ND	2.17	ND	ND	ND	**4.8**
GIL-79	ND	0.0094	0.0469	ND	1.94	ND	ND	ND	**3.2**
GIL-80/81	ND	0.00635	0.0508	ND	1.86	ND	ND	0.0233	1.6
GIL-82	ND	ND	0.0682	ND	0.679	ND	ND	ND	0.48
GIL-83	ND	**0.0116**	0.0480	ND	1.14	ND	ND	ND	**3.9**
GIL-84	ND	ND	0.151	ND	0.471	ND	ND	ND	0.79
GIL-85	ND	**0.0210**	0.169	ND	1.93	ND	ND	ND	**2.9**
GIL-86	ND	0.0045	0.0481	ND	0.644	ND	ND	ND	0.22
GIL-88	ND	0.0047	0.0499	ND	2.39	ND	ND	ND	1.9
GIL-89	ND	**0.0293**	0.302	ND	1.16	ND	ND	ND	**3.9**

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
GIL-1	ND	ND	ND	ND	ND	0.0030	ND	ND	ND
GIL-2	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-3	ND	ND	ND	ND	ND	0.014	ND	ND	ND
GIL-4	ND	ND	ND	ND	ND	0.017	ND	ND	ND
GIL-5	ND	ND	ND	ND	ND	0.0048	ND	ND	ND
GIL-6	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-7	ND	ND	ND	ND	ND	0.0046	ND	ND	ND
GIL-8	ND	ND	ND	ND	ND	0.0081	ND	ND	ND
GIL-10	ND	ND	ND	ND	ND	0.0068	ND	ND	ND
GIL-11	ND	ND	ND	ND	ND	0.020	ND	ND	ND
GIL-12	ND	ND	ND	ND	ND	0.00556	ND	ND	ND
GIL-13	ND	ND	ND	ND	ND	0.0037	ND	ND	ND
GIL-14	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-15/16	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-17	ND	ND	ND	ND	ND	0.019	ND	ND	ND
GIL-18	0.16	ND	0.047	ND	ND	ND	ND	ND	0.19
GIL-19	ND	ND	ND	ND	ND	0.0017	ND	ND	ND
GIL-20	ND	ND	ND	ND	ND	0.0010	ND	ND	ND
GIL-21	ND	ND	ND	ND	ND	0.0013	ND	ND	ND
GIL-22	ND	ND	ND	ND	ND	0.0018	ND	ND	ND
GIL-23	ND	ND	ND	ND	ND	0.00088	ND	ND	ND
GIL-24/25	ND	ND	ND	ND	ND	0.00275	ND	ND	ND
GIL-26	ND	ND	ND	ND	ND	0.0050	ND	ND	ND
GIL-27	ND	ND	ND	ND	ND	0.0015	ND	ND	ND
GIL-28	ND	ND	ND	ND	ND	0.0022	ND	ND	ND
GIL-29	ND	ND	ND	ND	ND	0.0029	ND	ND	ND
GIL-30	ND	ND	ND	ND	ND	0.0039	ND	ND	0.011
GIL-31	ND	ND	ND	ND	ND	0.0045	ND	ND	0.0070

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
GIL-32	ND	ND	ND	ND	ND	0.0014	ND	ND	0.0089
GIL-33	ND	ND	ND	ND	ND	0.0030	ND	ND	0.012
GIL-34/35	0.0505	ND	0.0051	/ND	ND	0.035	ND	ND	0.039
GIL-36	ND	ND	ND	ND	ND	0.0079	ND	ND	0.010
GIL-37	ND	ND	ND	ND	ND	0.0032	ND	ND	0.0094
GIL-38	ND	ND	ND	ND	ND	0.0042	ND	ND	0.013
GIL-39	ND	ND	0.0042	ND	ND	0.0079	ND	ND	ND
GIL-40	ND	ND	ND	ND	ND	0.0063	ND	ND	0.0081
GIL-41	ND	ND	ND	ND	ND	0.0096	ND	ND	ND
GIL-42	ND	ND	ND	ND	ND	0.0072	ND	ND	0.0082
GIL-43	ND	ND	ND	ND	ND	0.0016	ND	ND	0.0081
GIL-45	ND	ND	ND	ND	ND	0.0022	ND	ND	0.011
GIL-46	ND	-	ND	ND	ND	0.0031	ND	ND	ND
GIL-47	0.042	ND	ND	ND	ND	0.0031	ND	ND	0.020
GIL-48	ND	-	ND	ND	ND	0.0031	0.00035	0.00028	ND
GIL-49	ND	-	ND	ND	ND	0.00096	ND	ND	0.0059
GIL-50	0.037	-	ND	ND	ND	0.0043	0.00036	0.00027	ND
GIL-51	0.059	ND	ND	ND	ND	0.011	0.00017	ND	ND
GIL-52	ND	ND	ND	ND	ND	0.0030	ND	ND	ND
GIL-53/54	0.054	ND	ND	ND	ND	0.0125	ND	ND	ND
GIL-55/56	ND	-	ND	ND	ND	0.00195	ND	ND	0.0155
GIL-57	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-58	ND	ND	ND	ND	ND	0.014	ND	ND	0.037
GIL-59	ND	0.0014	0.0026	ND	ND	0.0018	ND	ND	0.063
GIL-60	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-61	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-62	ND	ND	ND	ND	ND	0.0108	ND	ND	ND
GIL-63	ND	ND	ND	ND	ND	ND	ND	ND	ND

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)
GIL-64	ND	ND	ND	ND	ND	0.0267	ND	ND	0.476
GIL-65	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-66	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-67/68	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-69	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-70/71	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-72	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-73	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-74	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-75	ND	ND	ND	ND	ND	0.0075	ND	ND	ND
GIL-76	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-77	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-78	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-79	ND	ND	ND	0.00038	ND	0.0126	ND	ND	0.0246
GIL-80/81	ND	0.00079	ND	ND	ND	ND	ND	ND	0.4045
GIL-82	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-83	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-84	ND	ND	ND	ND	ND	ND	ND	ND	ND
GIL-85	ND	ND	ND	ND	ND	0.0193	ND	ND	ND
GIL-86	ND	ND	ND	ND	ND	0.0032	ND	ND	ND
GIL-88	ND	ND	ND	ND	ND	0.0078	ND	ND	ND
GIL-89	ND	ND	ND	ND	ND	ND	ND	ND	0.0248

italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	∗^{18}O ($^{0}/_{00}$)	∗D ($^{0}/_{00}$)	Type of Chemistry
GIL-1	**447**	-	-	-	-	- 9.1	- 68	sodium-chloride
GIL-2	**-**	-	-	-	-	- 8.8	- 68	sodium-chloride
GIL-3	**387**	-	-	-	-	- 8.3	- 64	* see note
GIL-4	**722**	-	-	-	-	- 8.3	- 64	* see note
GIL-5	**301**	-	-	-	-	- 9.1	- 68	sodium-chloride
GIL-6	-	-	-	-	-	- 9.2	- 68	mixed-chloride
GIL-7	-	-	-	-	-	- 8.9	- 67	sodium-chloride
GIL-8	**380**	-	-	-	-	- 8.5	- 66	mixed-chloride
GIL-10	-	-	-	-	-	- 8.4	- 63	sodium-chloride
GIL-11	-	< 1	< 19	< 0.4	21.4	- 8.4	- 63	sodium-chloride
GIL-12	-	6.0	17.2	< 0.4	14.1	- 9.1	- 68	sodium-chloride
GIL-13	-	-	-	-	-	- 8.9	- 67	sodium-chloride
GIL-14	**1173**	1.1	< 3	ND	-	- 8.8	- 65	sodium-chloride
GIL-15/16	**909**	-	-	-	-	- 8.85	- 65	sodium-chloride
GIL-17	**564**	-	-	-	-	- 8.3	- 63	sodium-chloride
GIL-18	**361**	4.2	6.8	ND	-	- 9.2	- 67	sodium-chloride
GIL-19	**768**	-	-	-	-	- 9.2	- 67	sodium-chloride
GIL-20	**1316**	-	-	-	-	- 9.1	- 66	sodium-chloride
GIL-21	**1580**	3.3	6.0	0.9	ND	- 8.9	- 66	sodium-chloride
GIL-22	**762**	-	-	-	-	- 9.0	- 66	sodium-chloride
GIL-23	**684**	-	-	-	-	- 9.4	- 68	sodium-chloride
GIL-24/25	**1049**	-	-	-	-	- 9.15	- 68	sodium-chloride
GIL-26	**965**	-	-	-	-	- 8.9	- 66	sodium-chloride
GIL-27	**975**	-	-	-	-	- 9.3	- 68	sodium-chloride
GIL-28	**406**	-	-	-	-	- 9.1	- 67	sodium-chloride
GIL-29	**564**	-	-	-	-	- 9.1	- 67	sodium-chloride
GIL-30	**318**	-	-	-	-	- 9.0	- 69	sodium-chloride
GIL-31	**541**	-	-	-	-	- 9.3	- 68	sodium-chloride

LLD = Lower Limit of Detection
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level
* sodium concentrations were likely unreported in these samples

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	$*^{18}$ O $(^{0}/_{00})$	$*$ D $(^{0}/_{00})$	Type of Chemistry
GIL-32	**1,120**	-	-	-	-	- 9.2	- 69	sodium-chloride
GIL-33	**999**	-	-	-	-	- 9.3	- 69	sodium-chloride
GIL-34/35	**822**	ND	ND	ND	**280**	- 7.95	- 63.5	sodium-chloride
GIL-36	**551**	-	-	-	-	- 9.2	- 69	mixed-chloride
GIL-37	**705**	-	-	-	-	- 9.1	- 69	sodium-chloride
GIL-38	**602**	ND	ND	ND	16.7	- 8.5	- 65	sodium-chloride
GIL-39	**521**	-	-	-	-	- 8.2	- 64	sodium-chloride
GIL-40	**448**	ND	ND	ND	6.5	- 8.7	- 67	mixed-chloride
GIL-41	**730**	-	-	-	-	- 8.2	- 64	mixed-chloride
GIL-42	-	-	-	-	-	- 8.3	- 66	mixed-chloride
GIL-43	**634**	-	-	-	-	- 9.2	- 67	sodium-chloride
GIL-45	295	-	-	-	-	- 9.2	- 68	mixed-chloride
GIL-46	**749**	-	-	-	-	- 8.8	- 65	sodium-chloride
GIL-47	**592**	2.5	ND	1.2	28.3	- 9.1	- 67	mixed-chloride
GIL-48	**744**	-	-	-	-	- 9.1	- 67	sodium-chloride
GIL-49	**783**	2.6	ND	2.0	19.3	- 9.0	- 67	sodium-chloride
GIL-50	**682**	-	-	-	-	- 9.0	- 67	sodium-chloride
GIL-51	**457**	-	-	-	-	- 8.7	- 69	mixed-chloride
GIL-52	**1,348**	-	-	-	-	- 9.2	- 69	sodium-chloride
GIL-53/54	**484**	-	-	-	-	- 8.9	- 65	sodium-chloride
GIL-55/56	**493**	ND	ND	ND	ND	-8.85	- 65.5	sodium-chloride
GIL-57	**2,134**	4.4		3.6	22.6	-9.0	-66	sodium-chloride
GIL-58	**1,610**	-	-	-	-	-8.7	-66	sodium-chloride
GIL-59	109	-	-	-	-	-9.0	-66	sodium-chloride
GIL-60	**770**	ND	-	-	1.7	-8.9	-65	sodium-chloride
GIL-61	431	-	-	-	-	-8.9	-65	sodium-chloride
GIL-62	-	0.1	-	-	2.6	-8.4	-63	sodium-chloride
GIL-63	**761**	1.1	-	-	ND	-9.2	-67	sodium-chloride

LLD = Lower Limit of Detection
italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level

Appendix B. Groundwater Quality Data, Gila Bend Basin, 2012-2015----Continued

Site #	Radon-222 (pCi/L)	Alpha (pCi/L)	Beta (pCi/L)	Ra-226 + Ra-228 (pCi/L)	Uranium (µg/L)	$*^{18}$ O $({}^{0}/_{00})$	$*$ D $({}^{0}/_{00})$	Type of Chemistry
GIL-64	-	ND	-	-	**63.3**	-8.0	-62	sodium-chloride
GIL-65	-	-	-	-	-	-9.0	-66	sodium-chloride
GIL-66	**374**	-	-	-	-	-9.3	-69	sodium-chloride
GIL-67/68	-	-	-	-	-	-9.1	-67	sodium-chloride
GIL-69	-	-	-	-	-	-8.8	-67	sodium-chloride
GIL-70/71	**792.5**	ND	-	-	7.9	-9.4	-71	sodium-chloride
GIL-72	-	-	-	-	-	-9.1	-69	sodium-chloride
GIL-73	-	-	-	-	-	-9.1	-69	sodium-chloride
GIL-74	-	-	-	-	-	-9.0	-68	sodium-chloride
GIL-75	-	-	-	-	-	-8.8	-68	sodium-chloride
GIL-76	-	-	-	-	-	-9.0	-68	sodium-chloride
GIL-77	-	-	-	-	-	-9.1	-69	sodium-chloride
GIL-78	**876.1**	0.4	-	-	ND	-8.6	-66	sodium-chloride
GIL-79	**756**	-	-	-	-	-9.3	-70	sodium-chloride
GIL-80/81	-	ND	-	-	**40.6**	-9.0	-69	sodium-chloride
GIL-82	-	-	-	-	-	-9.0	-69	sodium-chloride
GIL-83	-	-	-	-	-	-9.2	-69	sodium-chloride
GIL-84	-	-	-	-	-	-9.1	-69	sodium-chloride
GIL-85	-	-	-	-	-	-8.4	-65	sodium-chloride
GIL-86	-	-	-	-	-	-7.9	-65	sodium-chloride
GIL-88	-	-	-	-	-	-8.5	-67	sodium-chloride
GIL-89	-	-	-	-	-	-9.1	-68	sodium-chloride

LLD = Lower Limit of Detection
italics = constituent exceeded holding time
bold = constituent concentration exceeded Primary or Secondary Maximum Contaminant Level